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Contents

ICT COMPETENCIES FOR ACADEMIC E-LEARNING

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Abstract

Deployment of e-learning at universities requires university teachers and students to have adequate ICT (Information and Communication Technologies) competencies. Schools usually provide training for their staff in operating e-learning portals and creating courses, which is the necessary minimum for conducting distance education. On the other hand, schools do not offer any courses for students to improve their competencies necessary for e-learning, as they assume that the students' ICT competencies acquired during the three levels of schooling (elementary, lower secondary and upper secondary) are sufficient. The authors' observations demonstrate that this assumption is not necessarily true, particularly for students at faculties related to humanities and other specializations not of technical nature, such as medicine.

The article presents an overview of ICT competencies necessary for e-learning study, comparing them with theoretical competencies of a secondary school graduate. On the basis of a research project conducted at three medical universities in Poland, the authors present the facts, i.e. level of knowledge and practical skills in the field of ICT among students who participated in e-learning courses. As a result of the project, a proposal has been presented for modifying ICT education contents for future students, as well as a draft course carried on the university's LCMS portal to bridge the ICT competence gaps for effective distance education.

Keywords

ICT competences, e-learning, academic education, medical education, e-learning technologies, ICT, distance education

INTRODUCTION

Distance learning in its various forms, such as e-learning, b-learning, m-learning, is slowly becoming a regular component of the education system, including higher education. Universities perceive e-learning as an opportunity to reduce the costs of education, to improve the teaching standards, or to engage in continuous education (Mokwa-Tarnowska, 2014; Półjanowicz et al., 2013). On the other hand, the attractive shape of learning materials, often based on multimedia, delivered on e-learning portals, makes it popular among young people (Kołodziejczak et al., 2014; Leszczyński et al., 2016). Also, the ability to study any time, anywhere is highly appreciated by students and teachers alike.

Thus, it seems that introduction of distance learning has only positive aspects. Yet it should be borne in mind that this is a multi-staged process, involving significant expenses at its initial stages (Roszak et al., 2016-A; Roszak & Kołodziejczak, 2017). Preparation of IT infrastructure (servers, LAN with adequate bandwidth, computer rooms, software), and employing a group of

IT specialists - these costs must be accounted for by every organization that implements this education option. To create digital materials on a satisfactory level, to build ICT competence among the teaching staff - these are the tasks for the subsequent stage, which also requires financial expenditure (Kołodziejczak al., 2015; Roszak & Kołodziejczak, 2017).

One should not forget about the recipients of distance education and their ICT competencies that are necessary for them to be fully involved in the educational process (Rosman, 2013:253-254). The common assumption is that the competencies they acquired at the previous levels of education, i.e. elementary, lower secondary and upper secondary, are sufficient. However, based on the authors' observations, this assumption need not be consistent with facts, particularly with regard to students of humanities and other non-technical specializations, such as medicine (Roszak et al., 2016-B). The level of required ICT competencies of distance education participants depends on the advancement of technologies constituting the entire distance learning process management. The next section presents an overview of the technologies implemented in e-learning.

ICT COMPETENCIES OF DISTANCE LEARNING PARTICIPANTS VS. TECHNOLOGIES

An LCMS (Learning Content Management System) portal is implemented in order to smoothly and effectively manage distance learning. This is an online application for gathering and processing information, which operates at a single location (server machine, computing cloud). If the application is available as freeware, it can even be installed on local hardware. For example, if you have a server machine with the following items installed:

- Web server software;
- Database server software;
- Online application operating technology (e.g. PHP+Moodle, Java+OLAT);
- LCMS installation files,

then you can successfully proceed with installation, after checking in the documentation whether all the technology requirements have been fulfilled. A issue that goes beyond the framework of this paper is the performance analysis of such an installation, the number of user accounts that can be supported, and the number of courses that can be offered (Roszak et al., 2016-A).

Data processing by the LCMS application is initiated through the Internet from user workstations (by students, teachers). Users can work on any workstation with an Internet access, whether it is their personal PC, or a workstation in a laboratory at a learning organization, or a mobile device. After launching the Web browser, you need to enter the URL (Uniform Resource Locator) pointing to the resources of the Web server supporting the LCMS application. It should be noted here that the URL is given for automatic, context-free processing. Unavailability of the desired resource generates a relevant message. The user must understand the meaning of the error, i.e. whether they gave a wrong URL that needs to be corrected, or perhaps the resource has not been found on the specified server, or the server is currently unavailable. In such cases, the competence involving passive understanding of communication protocols is particularly useful.

Across the entire distance education process, a set of so-called online technologies will be used, namely:

- Selected programming languages for online application development. This competence is considered adequate if the user can differentiate between script languages and other languages, and knows their role in the application creation process.
- HTTP and encrypted HTTPS communication protocols. The competence of understanding the process of encryption and decryption of information.
- HTML tagging system, particularly managing forms.
- Audio and video file streaming.

The assumption is that online technologies operate without any user intervention, fully automatically, but they often require a decision to be taken regarding the (appropriate) operating mode. Identical messages are most commonly generated for the user, whether a student or a teacher, and decision-making capacity is required. A good example of this is a message pointing to a wrong or non-trusted certificate used in HTTPS message encryption. The right decision to take can be specified, and this is usually done by LCMS portal administrators, yet with other related messages the user is helpless again. These situations discourage users, cause time waste and, consequently, lack of a positive attitude towards distance learning.

Generally, users (students, teachers) only launch the browser process on their workstations (typically FireFox, Chrome, Internet Explorer) and launch the LCMS application processes through entering the server URL. A configuration issue message can be generated at each individual workstation. The LCMS portal administrator is not usually capable of providing extended training to users in real time; therefore, they should have the appropriate competencies already when starting their distance learning experience. The following ranges of competence are mainly required:

- Managing add-ons in browsers;
- National character set coding;
- Enabling script programming language interpreters;
- Receiving streamed media,
- Managing security options.

A good example that illustrates inadequate competencies in the above mentioned range is when a user reports a “white blank field” in the browser window where a video file should be played. E-mail exchange between the user and the administrator to determine the cause and to eliminate the problem can sometimes take a few days.

Thus, a question emerges of whether a secondary school graduate is prepared for the role of distance learning participant.

COMPETENCIES OF A SECONDARY SCHOOL GRADUATE VS. DISTANCE LEARNING

Students can acquire the necessary ICT competencies during the *computer classes*, followed by the subject *computer science*, taught at the particular subsequent stages of education. The syllabus for ICT education for schools in Poland is defined in Regulation of the Minister of National Education of 23 December 2008 concerning “the syllabus for kindergarten education and general education in the particular types of schools”. The construction of the syllabus for *computer science* involves spiral education which guarantees continuous development of the student’s competencies. Thus, as early as at the lower secondary education stage (stage III of the education system), the student will acquire knowledge and skills in the following fields (Official Gazette of the Republic of Poland, 2009):

- Safely using a computer and software, using a computer network,
- Communicating with a computer and information and communication technologies, including setting up and configuring an e-mail account in an online portal, and participation in discussions on forums,
- Searching, gathering, selecting and processing information from various sources, and participation in creating online resources,
- Problem solving and decision making with the use of a computer,
- Using a computer and educational software and games for expanding knowledge and skills in various fields and pursue the student's interests,
- Evaluate the advantages and hazards arising from the development of information technologies and common access to information, as well as ethical and legal aspects of protection of intellectual property and data protection, as well as signs of cybercrime.

The subject *computer science* at this level of education is taught at 2 hours a week and is expected to provide solid grounds for further development of the student's IT competencies.

Stage IV of education (upper secondary school) is divided into two levels for *computer science*, namely basic and advanced. The basis level of education covers all secondary school students, while the advanced level applies to selected grades, e.g. specializing in IT or technical. The scope of research presented in the article covered university students of medicine, who had usually attended classes specializing in natural sciences (biology/chemistry) in their secondary schools, and participated in the basic course in computer science. Therefore, further in the analysis, we will only review the goals and contents of computer science training on this level. The subject is taught at 1 hour a week, for one year. The learning goals of the fourth stage are equivalent to those pursued at the previous stage of education, i.e. in the lower secondary school. On the other hand, contents are expanded with such areas as: creating and editing graphics, multimedia (sound, video, presentations), relational database handling or using resources published on distance learning portals. A secondary school graduate should theoretically have the knowledge and skills enabling him or her to take an active part in the e-education process (see Table 1).

Table 1: Comparison of ICT competencies of a secondary school graduate with the needs of a distance learning participant

ICT competencies necessary for a distance learning participant	Competencies of a secondary school graduate that are useful for a distance learning participant
Distinguishing script languages and understanding their role in the development of web applications Basic knowledge of HTTP and HTTPS communication protocols, understanding the process of encryption and decryption of information	Using basic services in a local and wide area network, related to access to information, sharing information, and communication
Installing and configuring software, e.g. installing a web browser and managing plugins	Using basic operating system and utilities services for managing resources (files) and installing software

Organizing and archiving data and programs, applying antivirus protection	Searching for and launching programs, organizing and archiving data and programs, applying antivirus protection
Creating network resources, Understanding the process of communication with an application server for downloading and copying files, Knowledge of the role and methods of encoding of national characters for different languages, ability to change the code page of a text file	Creating network resources related to one's education and interests
Ability to communicate with other users via e-mail, forum, chat, and in certain specific cases - ability to use Skype or teleconferencing systems	Using communication and information technologies for communicating and collaborating with teachers, learners and other persons (e-mail, forum, chat)
Knowledge of the principles of handling multimedia files, i.e. downloading and playing from online sources, Understanding the concept of audio and video streaming and role of audio/video codecs	Using multimedia devices, e.g. for recording/playing audio and video
Using the educational resources published on distance learning portals	Using the educational resources published on distance learning portals
Knowing the legal regulations concerning use of information and communication technologies, particularly concerning the security and protection of data and information on a computer and in computer networks Ability to manage a browser's security settings	Knowing the legal regulations concerning use of information and communication technologies, particularly concerning software distribution, cybercrime, confidentiality, the security and protection of data and information on a computer and in computer networks

However, the actual level of conveying the teaching contents at stage III and IV of the education system largely depends on the teacher's professional background. At the moment, there is a visible trend in the Polish elementary and secondary school system for teachers to acquire qualifications/certification for teaching more than one subject, usually 2-3 of them, e.g. mathematics and computer science, or physics, technologies and computer science. This trend works perfectly when elements of information technologies are incorporated in the syllabus of other subjects. However, it may have an adverse effect on the level of teaching computer science when these classes are taught e.g. by a biology teacher who has been certified for teaching computer science at postgraduate courses only.

In addition, spiral education, which is reasonable in terms of assumptions, often leads in practice to the same contents being repeated at the subsequent levels of education. All depends on the teacher's abilities and creativity. Based on the authors' experience, university students in their first years of study, particularly of humanities and other non-technical faculties, have difficulties using an educational portal, are wary of working with new applications, have problems with playing media files. The findings of a study aimed at diagnosing the ICT-related problems among the students of three medical universities in Poland are presented in the following section.

ICT PROBLEMS DISCOVERED AMONG STUDENTS AT MEDICAL UNIVERSITIES

What kinds of gaps exist among medical students regarding their ICT competencies necessary for pursuing the education process through e-learning? The authors of the paper are trying to answer this question in this part of the paper on the basis of their practical experience with e-learning at three Polish medical schools: Poznan University of Medical Sciences, Medical University of Bialystok and College of Health Sciences of Collegium Masoviense in Zyrardow.

Materials and methods

The study was conducted after e-learning and blended-learning classes using OLAT (Online Learning And Training) and MOODLE, in the years 2008-2016. The classes under review were taught at the following faculties: medicine, medical emergency services, physical therapy, nursing, obstetrics. Among the students of medicine, there were Polish language speakers as well as foreigners in MD (Doctor of Medicine) Program in English at the Poznan University of Medical Sciences. These were the first remote classes attended by all of the participating students. They had never passed any preparatory courses at their Universities that would prepare them for participation in e-learning.

Over 1600 students participated in the study (1060 students from Poznan University of Medical Sciences, 492 students from Medical University of Bialystok and 100 students from College of Health Sciences of Collegium Masoviense). The study was conducted on the basis of interviews with the 18 teachers (9, 8 and 1, respectively) and 7 administrators (4, 2 and 1, respectively) who participated in implementation of the education process. The authors askd the respondents to describe all the problem cases encountered by their students during the learning process. Some of the problems reported by students were registered in the surveys to evaluate the classes, or communicate orally or via e-mail.

Results

Below is a list of key ICT-related problems and extraordinary circumstances which the participants of e-courses were unable to handle. These problems prove the lack of adequate ICT competencies for working in an e-learning environment. The analysis was carried out on the basis of the classification of ICT competencies necessary for the receiving end of distance education, which was proposed by the authors in 2012 (Ren-Kurc et al., 2012).

Problems

<u>Category A</u> - Launching processes and applications.
The students would mostly encounter problems related to:

- Handling learning materials offered as SCORM packs - problems with the opening procedures,
- Multimedia presentations opening only on half of the screen - problem with having to install additional plug-ins,
- Problems with playing the multimedia files on the students' private devices,
- No direct access to the online course on the portal - students' inability to organize their own work on the portal,
- Missing test and self-test grading lists, which prevent ongoing monitoring of the student's accomplishment - failure to become acquainted with the required options of the portal applications, which generally offer such processes.

Category B - Understanding the flow of communication on the Internet with the discernment of the used services.
The students would mostly encounter problems related to:

- Logging on to the LCMS portal - problems with account password recovery, reset or change, wrong log-out procedure used, or typos in entering the URL of the LCMS portal,
- Ways of using the forum - inability to handle a public and private discussion forum,
- Forum / mailbox - inability to differentiate between the two applications and their functions for communication in the learning process,
- Closing tests or surveys without a final confirmation of uploading data to the server - a warning message is generated,
- Replying to e-mail messages sent by automatic portal account - this type of reply will not reach the teacher.

Category C - Knowledge of basic HTTP protocol communication client applications (commonly known as browsers).
With the gaps in the students' knowledge in this area, the following problems would occur:

- Problems with connection breaking, learning materials crashing, tests "disappearing", and student registration to course "services". As a consequence, communication must be re-established and some tasks have to be repeated (e.g. filling different forms),
- Dealing with e.g. hotspot - there was the issue with pointing a cursor to a selected location on an image.
- "Invisible image" - the displayed image is incomplete (image size exceeds the page window size),
- Remembering passwords at public workstations,
- Problems with uploading files to portal resources (open-ended tasks for evaluation).

Category D - Installation and use streaming media client software, commonly known as multimedia.
The students would mostly encounter problems in the following circumstances:

- Video files would not open correctly for some students, for such reasons as missing codecs, etc.,
- Using mp4 resources - there were many questions and uncertainties while using them in the early stages of learning,
- Video does not stream - streamed media application in the client web browser does not work. Lack of sufficient competence to be able to install plugins in browsers.

Discussion

The table below presents the distribution of the problems observed at each of the three Universities under review. The Table 2 shows the percentages of problems in the given category within the whole group of problems reported in the study (total). Sometimes a single problem would incorporate certain component parts from two categories of ICT competencies. Some of the category B and C problems related to handling the application interface could be gathered into a new category E - "Using online applications".

Table 2: The distribution of the problems observed at each of the three Universities

Medical University	Lack of ICT competencies			
	Category A	Category B	Category C	Category D
Poznan	33%	67%	22%	11%
Bialystok	29%	29%	29%	13%
Zyrardow	0%	60%	60%	20%

Research confirms that medical university students have certain gaps in their ICT competencies, which makes it difficult for them to be efficient participants of e-learning courses. Analysis has shown that the Universities covered by the research project differ in terms of the source of primary problems diagnosed among the students. The differences thus revealed would be worth studying in the future in terms of determining their source.

CONCLUSION

Distance learning requires the participants to have certain knowledge and skills which often extend beyond the range of ICT competencies they acquire during the earlier stages of their education. To eliminate the problems thus caused, the authors suggest the following two complementary solutions:

1. To broaden the contents of the *Information Technology (IT)* course offered to university students in their initial years,
2. To prepare an e-course that would be mandatory for those faculties where *Information Technology* is not taught.

Re: 1. A compulsory course IT is offered to students in their 1st or 2nd year of study, at most faculties of the Polish universities, with 30 class hours. The primary purpose of this course is to present the applications of information and communication technologies to students of the given faculty in their future professional work. With the learning material extended with skills useful for a distance learning participant, the students could be better prepared for this role. This type of arrangement does not entail any additional expenses and is beneficial for the university itself.

Re: 2. Mandatory participation in an e-course would enable students to fill the gaps in their ICT competencies. However, this type of arrangement involves extra costs for the university to prepare and facilitate the course.

In 2017, the Polish school system underwent another reform in terms of organization and syllabus. It should be hoped that the new syllabus structure will account for the increasing need to improve ICT competencies in the range necessary for engaging in distance learning.

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REFERENCES

Kołodziejczak, B., Roszak, M., Kowalewski, W., & Ren-Kurc, A. (2014). Educational multimedia materials in academic medical training. *Studies in Logic, Grammar and Rhetoric on Logical, Statistical and Computer Methods in Medicine*, 39(52), 105–121.

Kołodziejczak, B., Roszak, M., Kowalewski, W., Ren-Kurc, A., & Bręborowicz, A. (2015). Participants academic distance education - case study. *Technics, Technologies, Education, Management*, 10(2), 242–249.

Leszczyński, P., Gotlib, J., Kopański, Z., Wejnarski, A., Świeżewski, S., & Gałązkowski, R. (2016). Analysis of Web-Based Learning methods in emergency medicine: randomized controlled trial. *Arch Med Sci*, doi: 10.5114/aoms.2015.56422.

Mokwa-Tarnowska, I., (2014). Support structures and effectiveness of e-learning. *E-mentor,* 2(54), 34–39, (in Polish).

Official Gazette of the Republic of Poland no. 4, item 17 (2009). Available from: http://www.dziennikustaw.gov.pl/DU/2009/s/4/17

Półjanowicz, W., Mrugacz, G., Szumiński, M., Latosiewicz, R., Bakunowicz-Łazarczyk, A., Bryl, A., & Mrugacz, M. (2013). Assessment of the Effectiveness of Medical Education on the Moodle e-Learning Platform. *Studies in Logic, Grammar and Rhetoric on Logical, Statistical and Computer Methods in Medicine*, 35(48), 203–214.

Ren-Kurc, A., Kowalewski, W., Roszak, M., & Kołodziejczak, B. (2012). Building Digital Content for E-Learning. Information and Communication Technologies (ICT) Competence. In Smyrnova-Trybulska, E. (Sc. Ed.), *Monograph: E-Learning for Societal Needs* (pp. 201–212). Katowice-Cieszyn: University of Silesia.

Rosman, P. (2013). Some Aspects of ICT Integration into Education. In Kapounová, J. & Kostolányová, K. (Ed.), *Information and Communication Technology in Education: Proceedings of the 2013 ICTE Annual Conference* (pp. 252–260). Ostrava: University of Ostrava.

Roszak, M., & Kołodziejczak, B. (2017). Building a course with multimedia resources-the working time analysis on the example of the pathophysiology course. In Hrubý, M. (Ed.) *Distance Learning, Simulation and Communication 2017, Proceedings (Selected papers).* Brno: University of Defence, in press.

Roszak, M., Kołodziejczak, B., Kowalewski, W., & Ren-Kurc, A. (2016-A). Implementation of e-learning portal for academic education and lifelong learning. *Int. J. Continuing Engineering Education and Life-Long Learning*, 26(2), 135–152.

Roszak, M., Kołodziejczak, B., Kowalewski, W., Ren-Kurc, A., Półjanowicz, W., Leszczyński, P., & Bręborowicz, A. (2016-B). Participants medical distance education - ICT competences. *11th Conference on Technologies of Knowledge Exploration and Representation*. *Summaries* (pp. 14–15), September 7-10, 2016, Hołny Mejera, Poland (in Polish).

IMPLEMENTABLE PRINCIPLES OF SYSTEMS THEORY IN EDUCATIONAL TOOLS FOR ADVANCED MATHEMATICS

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Abstract

In the technical fields of studies, the linear differential equations may be explained in the advanced parts of the mathematical courses in the Bachelor's degree programs. An important part of this theory is a set of the linear differential equations. This topic can be more difficult for an understanding of its practical aspects. The aim of this paper is a proposal of an educational tool in form of a software simulation of sets of the linear differential equations using principles of the systems theory in a free-available software Scicos. The proposed model in Scicos can primarily be an inspiration for teachers; however, students may verify the analytical solved examples by this tool. This presented educational approach based on the systems modelling may be useful for students, which can better understand the principle of sets of the linear differential equations in the mathematics.

Keywords

Bachelor's mathematics, free-available software, modelling, Scicos, set of linear-differential equations, systems theory.

INTRODUCTION

Sets of the linear differential equations (Lakshmikantham et al., 2004) may be included in a mathematical education in the Bachelor's degree programs of the technical fields of studies. In this advanced topic, an explanation may be more difficult. The practical aspects can be demonstrated as a modelling of systems (Corriou, 2004) for the simulation purposes. The most appropriate example can be a modelling in the field of the weather forecasts (Brunet & Sills, 2017), where sets of the differential equations are utilized.

The advanced parts of a mathematical education may be more complicated; however, their practical aspects can be suitably implemented using the principles of the systems theory (Kucera, 1991). In this methodology, a system (Viteckova & Vitecek, 2015) is an entity, which has an input and an output. These parts of systems are able to transport information. Each system is able to transform an input to an output depending on its system parameters (Gazdos & Facuna, 2015). A mathematical model of the system with these parameters can be represented by a linear differential equation (Bronson, 1994). This form presents a parametrized object with a general input and with a specific transformed output by its dynamics. Then the linear differential equations fulfil a role of relations between two real functions of the real variables. Where these variables are expressed in the time area. For these purposes, Laplace transformation (Ortigueira, 2016) is used for the rewriting of the linear differential equation into a suitable form of an algebraic equation. In the algebraic form of the equation, a model is expressed by a transfer function (Fikar & Unbehauen, 2002) with variable *s*.

In case of sets of the linear differential equations (Lakshmikantham et al., 2004), a multidimensional model can be proposed. Instead of one transfer function, a transfer function matrix (Ataei & Enshaee, 2011) of the transfer functions can be built. A count of these particular transfer functions has a linear dependence on number of the linear differential equations in the set. After application of Laplace transformation, the same number of equations is only transformed from the form with operations of derivation to the algebraic form with the polynomial structure. This multivariable model has an ordered structure, which is suitable for the modelling purposes.

For the system modelling, a free-available software Scicos (Wenjiang, L. et al., 2009), which is a part of a software Scilab, is a suitable possibility for the technical fields of education. This software suitably applies principles of a circuit system modelling with respect to aspects of the systems theory. Using this software, the educational problems from the advanced parts of mathematics can be simulated. This software environment does not required knowledge of the system theory principles, because users only build objects and connections or set parameters of entities.

The mathematical teacher can build own examples using aspects of the systems theory, which are demonstrated in this paper. The proposed approach explains this utilization based on a transformation of set of the linear differential equations to the form of a transfer function matrix, which is an implementable form for the modelling purposes for Scicos. The first advantage may be an application of this presented modelling possibility in the education process. The presented approach can be also helpful for the verification purposes for students in the Bachelor's mathematics.

POSSIBILITIES OF MODELLING OF SET OF LINEAR DIFFERENTIAL EQUATIONS IN MATHEMATICS

In the technical fields, principles of simulation (Corriou, 2004) are based on a time variable. Therefore, Laplace transformation (Ortigueira, 2016) is used for this modelling purposes instead of Fourier transformation (Azooz, 2012). The reason is a time causality with the zeros initial conditions for each linear differential equation (Bronson, 1994).

Laplace transformation is able to transform a linear differential equation (1) with a time variable *t* to an algebraic polynomial equation (2) with variable *s*. Where an input signal *u* and an output signal *y* are the real functions of a time variable *t* and are the important parts of a system entity. Signals are denoted by *Y*(*s*) and *U*(*s*) after Laplace transformation. Parameters have a form of $a_i, b_j, i \in \langle 0,..,n \rangle, j \in \langle 0,..,m \rangle$. Where $m < n$ for purposes of a physical causality (Kucera, 1991).

$$a_n y^{(n)}(t) + ... + a_1 y'(t) + a_0 y(t) = b_m u^{(m)}(t) + ... + b_1 u'(t) + b_0 u(t) \tag{1}$$

$$a_n Y(s) s^n + ... + a_1 Y(s) s + a_0 Y(s) = b_m U(s) s^m + ... + b_1 U(s) s + b_0 U(s) \tag{2}$$

If is considered equation (3), the mathematical expression (2) of a system-dynamical behavior (Kucera, 1991) can be written in form (4). Description (4) is a transfer function (Fikar & Unbehauen, 2002). Parameters included in this transfer function can be set in a modelling software in the similar form of this polynomial fraction (4). The linear differential equation used to usually have a second order for purposes of a technical practices.

$$G(s) = \frac{Y(s)}{U(s)} \tag{3}$$

$$G(s) = \frac{b_m s^m + ... + b_1 s + b_0}{a_n s^n + ... + a_1 s + a_0}; m < n \tag{4}$$

In case of set of linear differential equations (Lakshmikantham et al., 2004), the modelling possibilities have the similar principles. However, a system, which is expressed by this set, has a multidimensional structure. In figure 1, the structure of a multidimensional system with 2 inputs and 2 outputs can be seen. Where a dimension of model is determined by a count of particular transfer functions $G_{kl}(s)$. Indices *k* and *l* express the particular connected output and input in this order of indexing. The input signals u_1, u_2 and the output signals y_1, y_2 are the real functions of a time variable *t*.

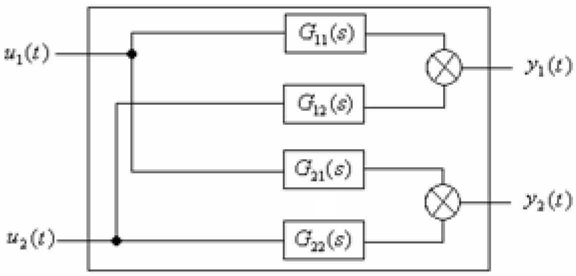

Figure 1: Structure of Multidimensional System Representing Set of Linear 2 Differential Equations

Laplace transformation is applied on each linear differential equation in set (5). In comparison with a one-dimensional case, the algebraic equations (6) have a form (7) after a vectorization. Signals are denoted by $Y_1(s), Y_2(s)$ and $U_1(s), U_2(s)$ after Laplace transformation. Parameters have a form: $a_{1i}, b_{1j}, a_{2i}, b_{2j}, c_{1i}, d_{1j}, c_{2i}, d_{2j}, i \in \langle 0,.., n \rangle, j \in \langle 0,.., m \rangle$.

For an equality of (8), a final model of the multidimensional system can be expressed as (9). After the matrix operations, the final transfer-function matrix (Ataei & Enshaee, 2011) has a unified form (10).

$$\left.\begin{array}{l} \left.\begin{array}{l} a_{1n} y_1^{(n)}(t) + ... + a_{10} y_1(t) + c_{1(n-1)} y_2^{(n-1)}(t) + ... + c_{10} y_2(t) = \\ = b_{1m} u_1^{(m)}(t) + ... + b_{10} u_1(t) + d_{1(m-1)} u_2^{(m-1)}(t) + ... + d_{10} u_2(t) \end{array}\right\} \\ \left.\begin{array}{l} a_{2n} y_2^{(n)}(t) + ... + a_{20} y_2(t) + c_{2(n-1)} y_1^{(n-1)}(t) + ... + c_{20} y_1(t) = \\ = b_{2m} u_2^{(m)}(t) + ... + b_{20} u_2(t) + d_{2(m-1)} u_1^{(m-1)}(t) + ... + d_{20} u_1(t) \end{array}\right\} \end{array}\right\} \tag{5}$$

$$\left.\begin{array}{l} \left.\begin{array}{l} a_{1n} Y_1(s) s^n + ... + a_{10} Y_1(s) + c_{1(n-1)} Y_2(s) s^{n-1} + ... + c_{10} Y_2(s) = \\ = b_{1m} U_1(s) s^m + ... + b_{10} U_1(s) + d_{1(m-1)} U_2(s) s^{m-1} + ... + d_{10} U_2(s) \end{array}\right\} \\ \left.\begin{array}{l} a_{2n} Y_2(s) s^n(t) + ... + a_{20} Y_2(s) + c_{2(n-1)} Y_1(s) s^{(n-1)} + ... + c_{20} Y_1(s) = \\ = b_{2m} U_2(s) s^m + ... + b_{20} U_2(s) + d_{2(m-1)} U_1(s) s^{(m-1)} + ... + d_{20} U_1(s) \end{array}\right\} \end{array}\right\} \tag{6}$$

$$\begin{bmatrix} a_{1n}s^n + \ldots + a_{10} & c_{1(n-1)}s^{(n-1)} + \ldots + c_{10} \\ c_{2(n-1)}s^{(n-1)} + \ldots + c_{20} & a_{2n}s^n + \ldots + a_{20} \end{bmatrix} \begin{bmatrix} Y_1(s) \\ Y_2(s) \end{bmatrix} = \\ = \begin{bmatrix} b_{1m}s^m + \ldots + b_{10} & d_{1(m-1)}s^{(m-1)} + \ldots + d_{10} \\ d_{2(m-1)}s^{(m-1)} + \ldots + d_{20} & b_{2m}s^m + \ldots + b_{20} \end{bmatrix} \begin{bmatrix} U_1(s) \\ U_2(s) \end{bmatrix} \tag{7}$$

$$\boldsymbol{G}(s) = \begin{bmatrix} U_1(s) \\ U_2(s) \end{bmatrix}^{-1} \begin{bmatrix} Y_1(s) \\ Y_2(s) \end{bmatrix} \tag{8}$$

$$\boldsymbol{G}(s) = \begin{bmatrix} a_{1n}s^n + \ldots + a_{10} & c_{1(n-1)}s^{n-1} + \ldots + c_{10} \\ c_{2(n-1)}s^{(n-1)} + \ldots + c_{20} & a_{2n}s^n + \ldots + a_{20} \end{bmatrix}^{-1} \cdot \\ \cdot \begin{bmatrix} b_{1m}s^m + \ldots + b_{10} & d_{1(m-1)}s^{m-1} + \ldots + d_{10} \\ d_{2(m-1)}s^{(m-1)} + \ldots + d_{20} & b_{2m}s^m + \ldots + b_{20} \end{bmatrix} \tag{9}$$

$$\boldsymbol{G}(s) = \begin{bmatrix} G_{11}(s) & G_{12}(s) \\ G_{21}(s) & G_{22}(s) \end{bmatrix} \tag{10}$$

A mathematical description (10) is an alternative expression of a set of the linear differential equations (5). Because each element of matrix $\boldsymbol{G}$ is a particular model $G_{kl}(s)$, these concrete models $G_{kl}(s)$ (Fig. 1) can be included as the concrete parts of a circuit schema in a modelling software.

IMPLEMENTABLE ASPECTS OF MODELLING IN FAVOR OF TOOLS IN MATHEMATICAL EDUCATION

Using Laplace transformation, settings of parameters of an educational scheme can be suitable determined. The dynamics of a system provides the corresponding signals (results of solving of a set of the linear differential equations) for the concrete input signals (the input functions in examples in context of expression (5)). Therefore, aspects of modelling in the systems theory are suitably implementable in favor of creating of tools in the advanced parts of the mathematical education.

Scicos (Wenjiang, L. et al., 2009) is a free-available software, which is a part of the Scilab software. The technical problems in the engineering practice can be suitable modelled using this tool. In this paper, the proposal of utilization of this software tool is presented in favor of a solving of examples in the advanced parts of the Bachelor's mathematical education.

The modelling possibilities of Scicos correspond with principles of the systems theory. In the mathematical description of the system, parameters of a model represent the system behavior and its dynamical properties. These parameters can be set in Scicos for each object, that is categorized as *Continuous Transfer Function*. The *Activation Clock* is necessary for the simulation purposes in the form of a circuit. There are many available elements e.g. for displaying of signals or for a connectivity of entities. In case of a modelling of a set of the linear differential equations (5), parameters of $G_{kl}(s)$ are set for each entity from a scheme as can be seen in figure 1.

RESULTS

The presented theoretical connection between a standard mathematical description of sets of the linear differential equations and modelling possibilities of the systems theory can be demonstrated on the concrete case in theory of sets of the linear differential equations.

For the educational purposes, the concrete mathematical example (11) is further considered. The construction of scheme (Fig.1) with settings of the model parameters of $G_{kl}(s)$ depends on a transformation of an original set of the linear differential equation (11) into a form of the algebraic equations (12) by Laplace transformation. After this step described in the methodology, equations are vectored to equation (13). Respecting the model description in form of (9), the final mathematical model of example (11) is in equation (15) after the matrix operations in equation (14). In model (15), the general inputs u_1, u_2 are considered. In the further simulation, the concrete definition of inputs is specified ($u_1 = t$; $u_2 = 5e^{-t}$).

$$\left.\begin{array}{l} 3y_1' + 2y_1 - y_2 = u_1; u_1 = t \\ 2y_2' + y_2 - y_1 = u_2; u_2 = 5e^{-t} \end{array}\right\}; y_2(0) = y_1(0) = 0 \tag{11}$$

$$\left.\begin{array}{l} 3Y_1(s)s + 2Y_1(s) - Y_2(s) = U_1(s) \\ 2Y_2(s)s + Y_2(s) - Y_1(s) = U_2(s) \end{array}\right\} \tag{12}$$

$$\left.\begin{bmatrix} 3s+2 & -1 \\ -1 & 2s+1 \end{bmatrix}\begin{bmatrix} Y_1(s) \\ Y_2(s) \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} U_1(s) \\ U_2(s) \end{bmatrix}\right\} \tag{13}$$

$$\begin{bmatrix} 3s+2 & -1 \\ -1 & 2s+1 \end{bmatrix}^{-1}\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = \underbrace{\begin{bmatrix} U_1(s) \\ U_2(s) \end{bmatrix}^{-1}\begin{bmatrix} Y_1(s) \\ Y_2(s) \end{bmatrix}}_{\boldsymbol{G}(s)} \tag{14}$$

$$\boldsymbol{G}(s) = \frac{1}{6s^2+7s+1}\begin{bmatrix} 2s+1 & 1 \\ 1 & 3s+2 \end{bmatrix} = \begin{bmatrix} \dfrac{2s+1}{6s^2+7s+1} & \dfrac{1}{6s^2+7s+1} \\ \dfrac{1}{6s^2+7s+1} & \dfrac{3s+2}{6s^2+7s+1} \end{bmatrix} \tag{15}$$

The model parameters of $G_{kl}(s)$ can be set in the scheme by each particular object, which can be built by elements *Continuous Transfer Function*, *Activation Clock*, *Single Display Scope* (Graph) and connections in Scicos. The input signals are created by *Ramp* and *Expression Block*. The final scheme can be seen in figure 2 and respects definition of model in figure 1.

Entities $G_{kl}(s)$ represented by a *Continuous Transfer Function* have settings in Scicos in this form: numerators have values: *3*s+2* or *1* or *2*s+1* and denominators have values *1+7*s+6*s*s*.

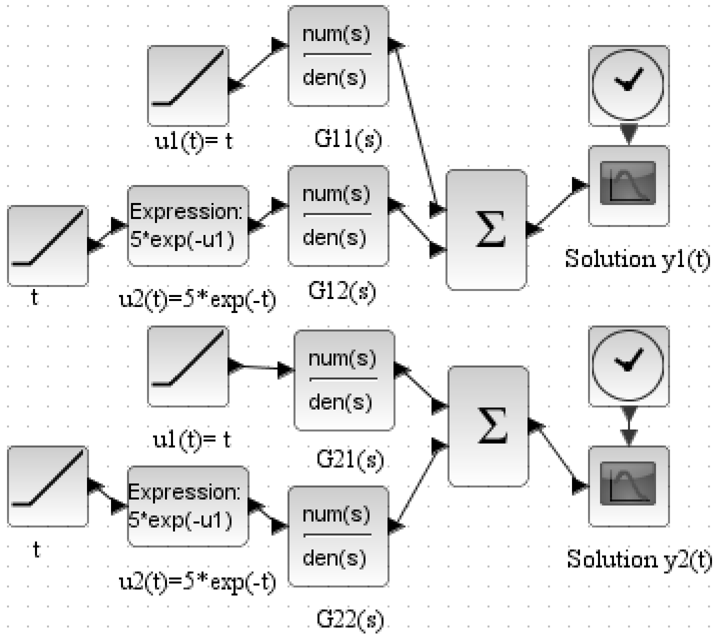

Figure 2: Demonstrated Example of Set of Linear Differential Equations in Scicos

This is a concrete possibility to creating of a simulation tool for a defined example for teachers. The students can share this scheme with a teacher and can try to verify solutions, which they determined using the analytical methods.

The correctness of the proposed approach can be verified in MS Excel for the analytical solution of example (11), which has a results in a vectored form (16). The output signals (a solution in an analytical solution of set of the linear differential equation (11)) from figure 4 are compared with the output variables in figure 3 displayed in Scicos.

$$\left.\begin{aligned} y_1 &= -(1+t).e^{-t} + 6.e^{-\frac{t}{6}} + t - 5 \\ y_2 &= (t-2).e^{-t} + 9.e^{-\frac{t}{6}} + t - 7 \end{aligned}\right\} \tag{16}$$

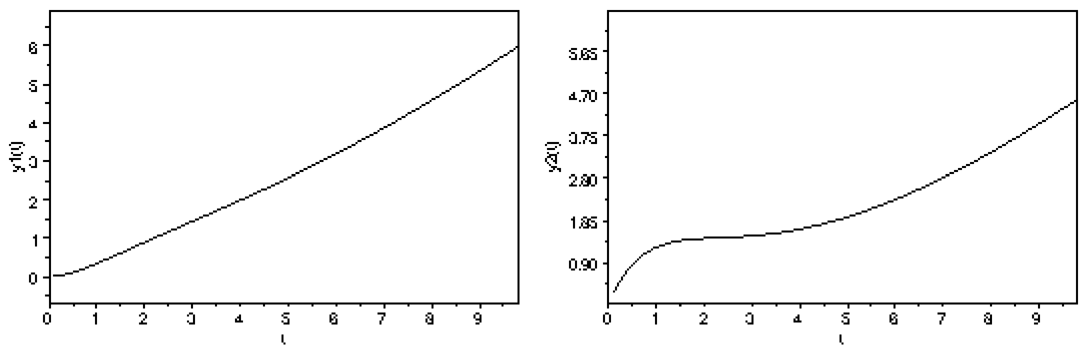

Figure 3: Output Signals of Multidimensional Model of Demonstrated Example in Scicos

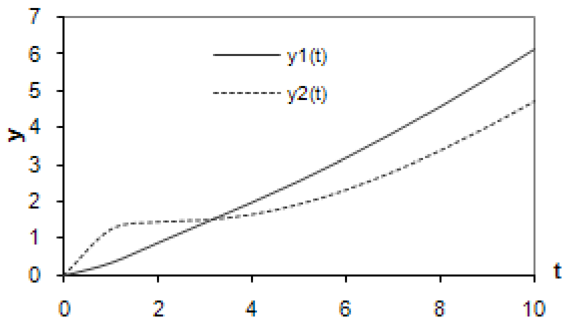

Figure 4: Analytical Solution of Demonstrated Example Displayed in MS Excel

CONCLUSION

In this paper, simulation of the set of the linear differential equations was proposed. The advantages of the presented approach can be suitable in favor of the mathematical education. Teachers of the advanced parts of mathematics can used this principle for the demonstrating purposes in the technical based courses. Students can verify the results of the analytical solutions of the mathematical examples using the proposed models, which can be shared by the teacher to students. The free-available modelling software Scicos, which is a part of the software Scilab, was applied for simulations in this paper. Utilization of this mathematical software support for purposes of explanation of sets of the linear differential equations is presented as a motivation for teachers of the advanced mathematics. The introduced theory is necessary for building the proposed scheme; however, the principle is not so difficult, because the methodology of Laplace transformation brings the reduction of differential equation to the unified form of the algebraic polynomial equations, which can be expressed using the implementable transfer functions for Scicos.

REFERENCES

Ataei, M., & Enshaee, A. (2011) Eigenvalue assignment by minimal state-feedback gain in LTI multivariable systems. *International Journal of Control*, *84*(12), 1956-1964. doi: 10.1080/00207179.2011.630026

Azooz, A. (2012) Experimentation with Fourier transformations. *International Journal of Electrical Engineering Education, 49*(2), 179-196. doi:10.7227/IJEEE.49.2.8

Bronson, R. (1994). *Schaum's outline of modern introductory differential equations*. New York, USA: McGraw - Hill.

Brunet, D., & Sills, D. (2017) A Generalized Distance Transform: Theory and Applications to Weather Analysis and Forecasting. *IEEE Transactions on Geoscience and Remote Sensing*, *55*(3), 1752-1764. doi:10.1109/TGRS.2016.2632042

Corriou, J. P. (2004). *Process control: Theory and Applications*. London, United Kingdom: Springer.

Fikar, M., & Unbehauen, H. (2002) Youla-Kucera design of decoupled control systems. *International Journal of Control*, 75(3), 213-218. doi:10.1080/00207170110108165

Gazdos, F., & Facuna, J. (2015) Web Application for LTI Systems Analysis. *Intelligent Systems in Cybernetics and Automation Theory, Vol 2, 348*, 101-109. doi:10.1007/978-3-319-18503-3_10

Kucera, V. (1991). *Analysis and Design of Discrete Linear Control Systems*. Prague, Czech Republic: Nakladatelstvi Ceskoslovenske akademie ved.

Lakshmikantham, V., Leela, S., & Devi, J.V. (2004) Stability theory for set differential equations. *Dynamics of Continuous Discrete and Impulsive Systems-Series A-Mathematical Analysis*, *11*(2-3), 181-189. Available from: www.math.uwaterloo.ca/~xzliu/v11n2-3a/d02lak.pdf

Ortigueira, M.D. (2016) Exponentials and Laplace transforms on nonuniform time scales. *Communications in Nonlinear Science and Numerical Simulation*, *39*, 252-270. doi: 10.1016/j.cnsns.2016.03.010

Viteckova, M., & Vitecek, A. (2015) Stability and pole dominance of control systems. *2015 16th International Carpathian Control Conference (ICCC)*, 580-585. doi:10.1109/CarpathianCC.2015.7145147

Wenjiang, L., Nanping, D., & Tongshun, F. (2009) The Application of Scilab/Scicos in the lecture of Automatic Control Theory. *1st International Workshop on Open-source Software for Scientific Computation*, 85-87. doi:10.1109/OSSC.2009.5416865

GRAPH ALGORITHMS IN PRIMARY SCHOOLS?

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Abstract

Abstract data structures are among the basic knowledge of every computer scientist and the Slovak Innovated State Educational Program in Informatics is trying to bring these concepts to pupils in the primary and secondary schools. One of these are graphs and graph algorithms, but it is not clear what types of tasks are suitable for pupils in lower secondary education. In the Bebras competition, tasks about the computer science basics have appeared since its beginning, so we have decided to analyze the graph tasks from the recent years in the category Benjamins and try to answer the questions: Is there a correlation between the age of the contestants and their solutions? Is there a gender-to-solution correlation? Which types of the tasks are suitable for fifth graders and which are better for older pupils? How can these tasks be used in the classroom?

Keywords

graph structure, graph algorithms, Bebras, lower secondary education, primary schools

INTRODUCTION AND THEORETICAL BASICS

The graph theory field is one of the basics of computer science often appearing in higher education, but increasingly it also gets into informatics at primary and secondary schools as a part of a strategy for building and developing computational thinking (Wing, 2011). In the school year 2015/2016, an Innovated State Educational Program (iSEP) (Štátny pedagogický ústav, 2014) was introduced in Slovakia, which responds to the European trends in Computing to bring more computer science into basic education. ISEP is divided into 5 fields and the graph theory is part of two of them - Representation and tools – Structures, and Algorithmic Problem Solving. In the first one, pupils should learn how to organize data into structures (e.g. graphs and trees), and to read and interpret data from them. In the second one, they should learn how to solve problems, select appropriate strategies, look for examples, think about different solutions, and so on – so it's a place for many graph algorithms. But how can we teach them to pupils in lower secondary education?

The iBobor (Bebras) competition (Kalas & Tomcsanyiova, 2009) has been a part of informatics in Slovakia for 10 years and it could provide us with an answer. Pupils meet with computer science problems in the competition and teachers often use the tasks as an inspiration for their lectures. Bebras assumes that pupils should be able to solve tasks without dependence on the learning style of the country, gender, or previous knowledge of computing, and many of the tasks are focused on algorithmic problems or concepts in computer science (Dagiene et al, 2014). However, there are some differences – in Benjamins category, pupils from 5th to 7th grade compete so tasks cannot be equally difficult for each of them. There are also studies

(Hubwieser & Mühling, 2015) that show that boys are better in harder tasks, tasks requiring spatial imagination, and they are more likely to guess the correct answer. In further research (Hubwieser, Hubwieser, & Graswald, 2016) defined boys' and girls' tasks and showed that boys were overall more successful. But the various studies (Dagiene et al., 2014), (Kalas & Tomcsanyiova, 2009), say that at the age of 10-13 there are no big differences between performance of boys and girls in the competition. We have therefore decided to examine what types of graph tasks are presented in the Slovak competition and how difficult they are for each age category, and we were trying to find out, if there exists some gender correlation.

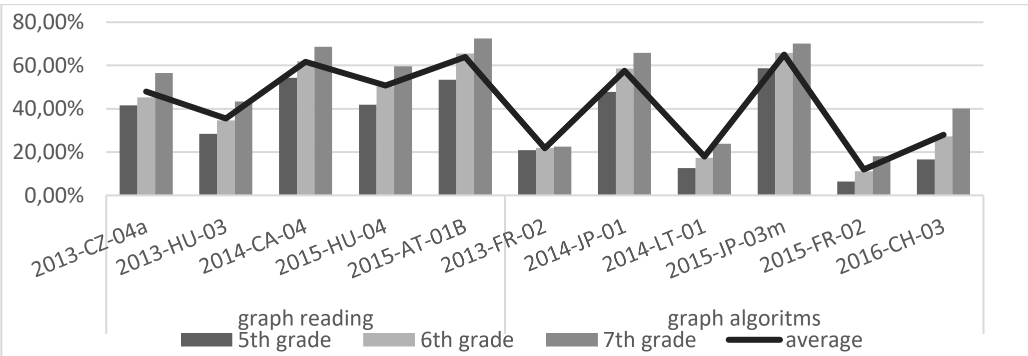
METHODOLOGY

We have divided the research into two parts. In the first, qualitative, we reviewed the tasks of the last four iBobor (2013/14 - 2016/17) competitions focusing on the Benjamin category and selected those in which a graph is the main part of the task. Tasks that used the graph but were testing another knowledge, such as programming robot in labyrinth, were ignored. We analysed whether the graph is used only as a structure, or it is required to use an algorithm or strategy to solve the task. Each task was first categorized into one group, then descriptions of the groups were introduced and tasks were recategorized if necessary. For tasks, which aim on the graph reading we consider tasks in which pupils should find the relationships between the data in the graph; analyse the graph with the use of some additional text information; or analyse the finite number of options that are directly visible. The graph algorithm group includes tasks that require pupils to try out all the options; choose a suitable strategy or design a solution algorithm; analyse more complex graphs (weighted graphs, graphs with restrictions, etc.); or create their own solution.

After selecting tasks, we quantitatively analysed the data for these tasks. We have determined overall results, results for each participating grade and gender correlation within groups.

RESULTS

In qualitative research, we selected 11 tasks, which are all listed in Table 1 below including summary and group classification. The age ranges in all four years were balanced – roughly one third for each participating grade, but the contest is more attractive for boys – on average, of all four years, 53% of those competing in this category were boys.

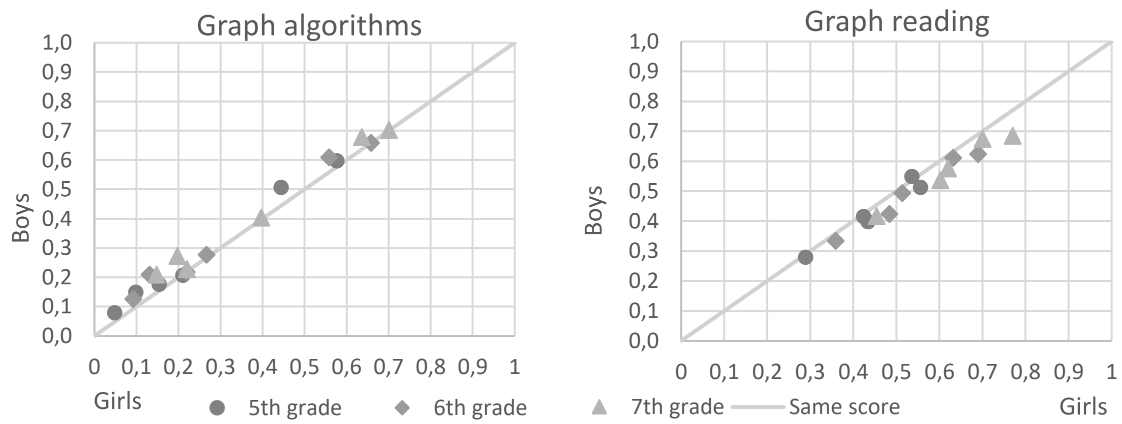


Graph 1: Task performance based on pupils grade

Performance in tasks for each grade is shown in Graph 1. Algorithmic tasks have been more often classified as harder, and the results are also consistent. The hardest task in the graph algorithms group were all interactive and the hardest one in the graph reading group was combining graph reading with eight-direction movement representation. The differences between the age groups are roughly similar, except for 2013-FR-02.

Table 3 – Classification of examined tasks (Difficulty: 1 = easy, 2 = medium, 3 = hard; Group: R = graph reading, A = graph algorithms; Type: I = interactive task, MC = multiple-choice)

Year	Task		Diffic.	Group	Summary	Type
2013/14	2013-CZ-04a	(Family Graph)	1	R	Family relationships graph	I
	2013-FR-02	(Beaver the Hobbit)	3	A	Shortest path with constrains	MC
	2013-HU-03	(Beebot)	3	R	Graph representation using 8-directional robot movement	MC
2014/15	2014-JP-01	(Traveling upriver)	2	A	Minimal path with constrains	MC
	2014-LT-01	(Dam)	3	A	Breath-First search	I
	2014-CA-04	(Bridges)	3	R	Path finding	MC
2015/16	2015-HU-04	(Trams)	1	R	Conditions interpretation	MC
	2015-AT-01b	(Super Power Family)	1	R	Graph analysis	MC
	2015-JP-03m	(Meeting)	2	A	Minimal path optimalisation	MC
	2015-FR-02	(Spreading Secret)	3	A	Minimal vertex cover	I
2016/17	2016-CH-03	(Primary health care)	3	A	Minimal vertex cover	I



Graph 2ab - Gender correlation of tasks' performance

Gender-to-solution correlation is illustrated in Figure 2ab, where we can see that boys were more successful in algorithmic problems and girls performed better in graph reading. Tasks with balanced performance were 2013-HU-03 and 2014-CA-04 in the graph reading group and 2013-FR-02, 2016-CH-03 and 2015-JP-03m from the graph algorithms group.

DISCUSSION AND CONCLUSION

We compared the results of 11 graph tasks from the last four iBobor competitions in Slovakia. We've found out that girls are slightly etter in graph reading tasks, boys are better in difficult tasks where a good strategy is needed, as other studies have confirmed (Dagiene et al., 2014). Minimal gender differences are in the tasks that combine these approaches. In the research

(Hubwieser et al., 2016) examined two same tasks as us. They were both labelled as boys' task, but the task 2014-CA-04 was solved better by girls in our sample.

Of all the tasks we have examined, tasks that contain a greater number of possible (or even correct) solutions are shown to be the most difficult. They included interactive tasks in which pupils should find minimal vertex cover (they should choose all the vertices) which could have caused more errors. Tasks that deal with optimization graph problems or breadth-first-search can also be included here. Reading oriented and multiple graphs and combinations of graphs with text or numeric description fall under medium tasks. Easy tasks included finding the minimum or the shortest paths (with a small number of options) and reading simple graphs. It is therefore advisable to introduce easier tasks in the fifth grade and to use task attractive for boys as well as for girls. In the sixth grade, we recommend adding more complicated algorithms and encouraging girls to try out the trial-error method. Seventh graders should be able to solve all proposed tasks, but especially in optimization problems and minimal vertex cover it is necessary to first explain the strategy.

In our research, we did not examine specific incorrect answer nor no response answer. This additional information could show what the most common mistakes are. However, we have managed to find out that at the age of 10 to 13 there are differences between boys and girls in the graph tasks, which is valuable both for pedagogical research and for pedagogues.

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REFERENCES

Dagiene, V., Mannila, L., Poranen, T., Rolandsson, L., & Stupuriene, G. (2014). Reasoning on Children ' s Cognitive Skills in an Informatics Contest : Findings and Discoveries from Finland , Lithuania , and Sweden. In Gülbahar Y., Karataş E., *Informatics in Schools. Teaching and Learning Perspectives. ISSEP 2014. Lecture Notes in Computer Science*, vol 8730. Cham: Springer.

Hubwieser, P., Hubwieser, E., & Graswald, D. (2016). How to Attract the Girls : Gender-Specific Performance and Motivation in the Bebras Challenge. In *Informatics in Schools: Improvement of Informatics Knowledge and Perception. ISSEP 2016* (pp. 40–52). Cham: Springer.

Hubwieser, P., & Mühling, A. (2015). Investigating the psychometric structure of Bebras contest: Towards mesuring computational thinking skills. In *Proceedings - 2015 International Conference on Learning and Teaching in Computing and Engineering, LaTiCE 2015* (pp. 62–69).

Kalas, I., & Tomcsanyiova, M. (2009). Students' Attitude to Programming in Modern Informatics. In *Proceedings 9th WCCE: World Conference on Computers in Education*.

Štátny pedagogický ústav. (2014). Informatika - nižšie stredné vzdelávanie. Retrieved May 29, 2017, Available from http://www.statpedu.sk/sites/default/files/dokumenty /inovovany-statny-vzdelavaci-program/informatika_nsv_2014.pdf

Wing, J. M. (2011, March). Research Notebook: Computational Thinking--What and Why? | Carnegie Mellon School of Computer Science. *The Link*. Available from https://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-and-why

THE 21ST CENTURY STUDENTS' TECHNOLOGICAL PREFERENCES

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Abstract

Information and communication technologies (ICT) play an important role in the teaching and learning practice, hence the increase in their adoption and use in education. Although the governments are increasing the budget towards ICT acquisition and implementation in education, the existing literature has limited descriptions about the technologies preferred by the current generation of students. Lack of this knowledge has resulted in a gap between the abundant quantities of ICTs and their usage that is minimal with regards to the learning of the current generation of students. The situation has led to the emergence of the second order digital divide, a disparity between the ICT access and use mainly at universities in the least developed countries. This is an indication of the existence of causal mechanisms requiring uncovering and redress in higher education institutions. This paper seeks to fill the gap in literature by establishing the technological preferences of the current generation of students for the benefit of both the related researchers and the institutions in need of realizing the returns from the technological investments. Quantitative data will be collected from the computer science undergraduate students currently enrolled at one of the universities in Zimbabwe, a least developed nation in Southern Africa that is making initiatives towards ICT enabled education despite the economic hardships faced. The ICTs popular in this context include the electronic learning systems facilitated by the learning management systems. The students' underutilization of these technologies is an indication of a problem that requires attention, hence the need to identify the students' technological preferences and establish how they compare to the currently implemented ICTs in the case institution. The research findings could provide strategies for reducing the prevailing second order digital divide, a problem of concern to both the digital divide researchers and the higher education institution management globally. The data collection will be through the lens of Archer's morphogenetic, an approach with the capacity to uncover both the causal mechanisms constraining and enabling the effective use of ICTs conducive to 21st generation of students.

Keywords

ICT preferences, 21st generation students, lease developed countries, teaching and learning, higher education, second order digital divide.

INTRODUCTION

For many centuries, the education sector has been providing skills for individual survival and economic development. Although the structures the brick and mortar structures have endured and are still a visible scenery, the generation of students currently enrolled in higher education institutions has changed with the current times. For example, these digital native students no longer appreciate the yester years' teaching and learning methods once so popular and effective.

The current students are frustrated by the teaching and learning strategies that are without Information and Communication Technologies (ICT). They find such strategies boring and unexciting. These students have been affectionately termed the digital natives (Prensky,2007 ; Prensky,2005) , a generation that has been born and bred in an environment proliferated with ICTs. The ICTs facilitate their collaboration, multi-tasking as well lifelong learning.

It is in response to these students' ICT demands that the governments have increased the budget towards ICT innovations in the education sector. Furthermore, the learning institutions have been adopting and implementing the ICT resource based teaching and learning strategies. Such strategies include the electronic learning, blended learning, mobile learning as well as cloud learning paradigms. Nevertheless, the general observation in the learning institutions particularly in the least developed countries demonstrates that these ICTs are underutilized in the teaching and learning. It is on this premise that this paper sought to find answers to the underlying question:

RESEARCH QUESTION

Despite the increase in the access to ICTs in education attributed to the reduced cost of the ICT resources, their ubiquity and affordability, the trend in teaching and learning is still based on the brick and mortar classroom set up. Even the use of the implemented ICTs is still at its infancy, hence the need to find the answers to the subsequent question:

What ICT enabled strategies do the 21st century students find useful for learning purposes?

The answers to the preceding questions are relevant to both the researchers and the decision makers in the universities. With regards researchers, there have been concerns about the emergence of the second order digital divide evident in the low uptake of the implemented ICTs in teaching and learning. These concerns are demonstrated in Table 1.

Table1: Level of usage in higher education institutions

Source	Observation
Leidner and Jarvenpaa, 1995	Academic institutions lag businesses in the use of ICTs to enhance effective teaching and learning
Cuban, Kirkpatrick, and Peck, 2001	High access to ICT resources seldom led to widespread use with most educators found to be occasional or nonusers.
Oliver, 2005	A ten-year retrospective on ICT in learning (1995-2005) found that use of ICT in teaching and learning was slow in 1995 and still appeared sporadic.
Conole and Alevizou, 2010	Despite the ICT infrastructure in HEIs the deployment of social media in the curriculum is not yet extensive across all aspects of teaching and learning.
Johnson et al, 2013	Students use ICTs to learn but are limited by educators who do not use new technologies for teaching and are apprehensive about working with new technologies.
Johnson et al, 2014	***ICTs are not being used to their full capacity in HEI where fully online schoolwork is still relatively rare and a***ccess to online resources is limited.
Mbengo, 2014	Despite this wide spread adoption of e-learning in university education, research on e-learning adoption suggests that it has not reached its full potential
Noguera, 2015	ICTs are used minimally and as supplementary tools to face-to-face method in HEIs

These studies concur with Bhuasiri, Xaymoungkhoun, Zo, Jeung, & Ciganek (2012) that the use of ICTs is still at its infancy teaching and learning, hence this paper's objective to establish the students' technological preferences, an area with a limited attention in Literature as indicated in Mbengo (2014) that there is limited literature on students' ICT perspectives. This study sought to fill this gap and inform educationists on future ICT considerations.

THEORETICAL BASIS

The data collection was guided by Davis, Technology acceptance model depicted in Figure 1.

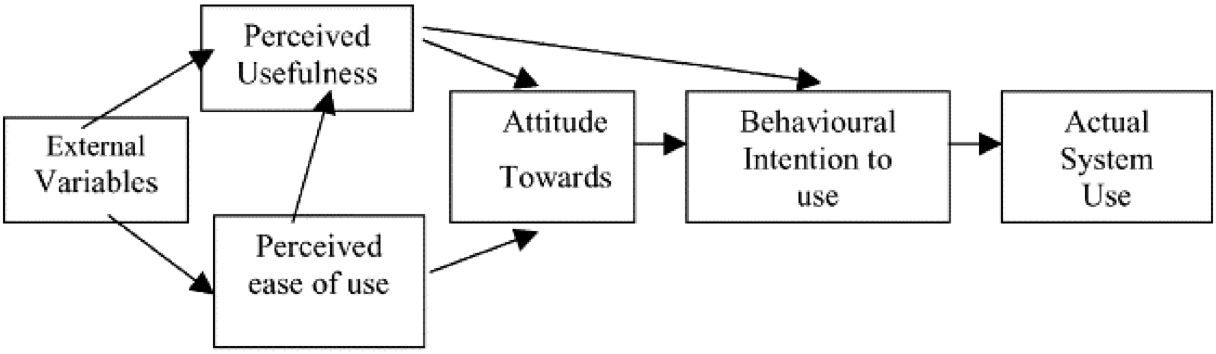

Figure 1 The Technology Acceptance Model, version 1 adapted from (Davis, Bagozzi, & Warshaw, 1989)

In Figure 1 shows that the students' ICT preferences are influenced by external variables and factors like perceived usefulness, percieved ease of use, attitude towards technology and the intention to use it.

METHODS

Quantitative data were collected through online questionnaires administered to a cohort of 100 students studying Computer Science at a Science and Technology university in Zimbabwe, a developing country in Southern Africa. A 100% response rate was achieved since the students could complete the questionnaires during their free time and there was no risk of losing the questionnaire stored on the students' mail server. A combination of open and closed ended questions guided by the Technology Acceptance Model questions relating the perceived usefulness, ease of use, students' attitudes and their intention to use the implemented ICT based system.

RESULTS

Responding to the question on awareness of the ICTs implemented in the institution, the students indicated their awareness of the Sakai Learning management system, which they however criticised of failing to meet their learning expectations. The students demonstrated frustration on the system that they criticised of non-flexibility, complexity and lack of value drawn from it. They indicated the difficulty in using the system due to its heavy dependence on the internet connectivity as well as localised nature such that access to the system was limited to campus environment. More so, students were not benefitting from the types of the system features such as tests that are mainly based on summative rather than formative type, hence hindering them from being innovative and creative. The system also cannot handle multiple users at the same time leading to inconvenience when it crushes.

Responding to the question regarding their preferences, the students indicated that the prefer using ICT resources that are compatible with their ubiquitous computing devices. They also prefer enrolling in a Google classroom, a platform with high flexibility conducive for a lifelong learning independent of time and place. The popular feature of this platform is the collaboration, enabling students to work on an assignment or project without a physical contact. Below is an extract of some of the open-ended questions depicting the value students draw from the Google classroom.

Being connected to other students and lecturers.
Real time notifications, tests, etc.
Ease of use
Hassle free,
Location independent,
Access to course material and tutorials

From the above extract, the students benefit from the emerging technologies more than the noe legacy LMS facilitated e-learning systems popular in higher education institutions in Africa. Their priorities are further shown in the extract below, a response to their ICT priorities.

it would be better if our lecturers could stream their lecturers
Timed assignments/tests should be available
Time limits need to be added for tests
Integration with SMS services for notifications

Access to electronic resources such as online databases and journals is another issue of high priority to the students. They indicated that such resources could improve their research capabilities, enhance learning and improve their learning activities. Popular among the cohort were the integration of You Tube audio and video lessons, a feature not activated in the institutional LMS, hence the students' negative attitude and lack of intention to use the system.

DISCUSSION

The survey results show that the 21st generation of students prefer teaching and learning strategies that enable them to actively participate in both problem solving and knowledge creation. The students despise not only the passive but also strategies that convert them into passive consumers of knowledge as characterised by the institutional LMS. This generation of students is well versed with technology, can multi task and learn better when appropriate ICTs such as the Google classrooms are integrated into their learning practice. Gone are the days when institutions could boast of such ICTs as the LMS for emerging technologies such as Google classrooms, You Tube and electronic resources. The ICT based systems considered to be value free, complex to use and not adding any learning value are resisted by students, hence the need for education institutions to cater for the students' preferences and needs if the returns on technological value could be gained.

CONCLUSION

The study established the 21st century students' technological preferences and found that the digital natives' priorities include the Google classrooms, You Tube services and the general study aids provided on line. Contrary to the LMS still common in the developing countries' education institutions, the students find their preferred systems to be useful. usable and adding value to their learning activities in accordance with the technology acceptance model concepts. The adoption and implementation of such ICT resources is widening the gap between ICT access and usage as they fail to serve the needs of the digital native students (Prensky, 2001) currently operating in digital society with labour market requirements demanding the integration of ICTs. The current generation of students yearn for appropriate skills relevant for survival in the information rich society. Nevertheless, existing literature shows that the least developed countries lag in the use of emerging technologies favoured by the generation of students in the teaching and learning. The institutions should take advantage of the proliferation of ICT devices that are compatible with the ICT resources available for free on the global network. More so the choice of ICTs for implementation in education should be guided and influenced by the intended users in this case the 21st century students if the prevailing digital divide is to be reduced.

REFERENCES

Bhuasiri, W., Xaymoungkhoun, O., Zo, H., Jeung, J., & Ciganek, A. P. (2012). Critical success factors for e-learning in developing countries : A comparative analysis between ICT experts and faculty. *Computers & Education*, *58*(2), 843–855. http://doi.org/10.1016/j.compedu.2011.10.010

Cuban, L., Kirkpatrick, H., & Peck, C. (2001). High Access and Low Use of Technologies in High School Classrooms : Explaining an Apparent Paradox. *American Educational Research Journal*, *38*(4), 813–834.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*, 982–1003.

Johnson, L., Adams Becker, S., Cummins, M., Estrada, V., Freeman, A., & Ludgate, H. (2013). *NMC Horizon Report: 2013 Higher Education Edition*. Austin, Texas.

Mbengo, P. (2014). E-learning Adoption by Lecturers in Selected Zimbabwe State Universities : An Application of Technology Acceptance Model. *Journal of Business Administration and Education*, *6*(1), 15–33.

Prensky, M. (2001). Digital Natives, Digital Immigrants, Part I: Do They Really Think Differently? *From On the Horizon (NCB University Press)*, *6*(1.9), 1–9.

Prensky, M. (2005). Listen to the Natives. *Learning in the Digital Age*, *63*(4), 1–6.

Prensky, M. (2007). How to teach with technology: keeping both teachers and students comfortable in an era of exponential change. In *Emerging Technologies for Learning volume 2* (pp. 40–47).

SOME ASPECTS OF ICT IN EDUCATION IN SLOVAKIA AND CHINA

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Abstract

The Information Communication Technology (ICT) in Chinese conditions is one kind of subject, the same as mathematics, Chinese, English, etc. We have in Slovakia the subject Informatics and generally, ICT is according Slovak curriculum implemented in every subject. ICT in China is a compulsory subject, it starts at the third grade in primary school till third. We would like to compare some selected aspects of ICT in Education in Slovak and Chinese conditions

Keywords

Information and Communication Technologies (ICT), Information Technologies (IT), ICT subject, China, Slovakia, ICT educational projects.

INTRODUCTION

If we implement Information and Communication Technologies (ICT) in Education, then for their effective use by pupils and students they need to have a certain level of computer and information literacy (Computer and Information Literacy - CIL). This problem has already been dealt with many countries around the world on different continents within the international comparative research ICILS - International Computer and Information Literacy Study and other international studies.

Information and Communication Technology (ICT) is often associated with the most sophisticated and expensive computer-based technologies. While definitions of ICT are varied, it might be useful to accept the definition provided by United Nations Development Program: "ICTs are basically information-handling tools- a varied set of goods, applications and services that are used to produce, store, process, distribute and exchange information" (see Reddi (2006)).

However, the special concept of ICT in education field refers to the new technology based on computer, communication, and network. Besides, IT is acronym of Information Technology and its mean is nearly the same as ICT (Information Communication Technology) or Information and Communication Technologies (ICTs), most of us are accustomed to call it as IT but not ICT/ICTs in China.

We use in Slovakia we use both terms ICT and IT. ICT is more general and IT will be used in State educational program ISCED 3 for subject informatics (see Štátny vzdelávací program Informatika (2008)).

METHODS OF SIMULATIONS IN THE EDUCATIONAL PROCESS

The subject Informatics has an important role in education because, like mathematics, it develops the students' thinking, their ability to analyse and synthesize, generalize, find appropriate problem solving strategies and verify them in practice. It leads to the precise expression of thoughts and procedures and their recording in formal writings, which serve as a general means of communication (see Infososkar (2017)).

The mission of computer science is to help students understand the basic concepts, procedures and techniques used to work with data and the flow of information in computer systems. It builds an informational culture, educates the efficient use of information civilization resources while respecting the legal and ethical principles of the use of information technologies and products. This mission is to be achieved through the joint action of computer science and the application of information technologies in the teaching of other subjects, interdisciplinary projects, all-school programs and school management (see also Turčáni, Magdin (2014)).

Systematic basic education in the field of informatics and the use of its tools will provide the same opportunity for the productive and full-fledged life of Slovak citizens in the information and knowledge society that we are building (see Infososkar (2017)). In the pedagogical literature, we encounter different approaches and a different understanding of the notion of material didactic means. In the broader sense, it is understood as "any subject or complex of material character that contributes immediately to the realization of the teaching process" those are all subjects that serve to illustrate the teaching and enable a more perfect, faster and more complex learning of the education in education processes, but also in self-learning processes "(see Bílek (2011)).

Information and communication technologies in education are widely used to acquire knowledge in contemporary education. The new model of computer learning was also achieved by the introduction of virtual laboratories in the field of education. Virtual Laboratories are focusing on virtualization of laboratory technology add a new dimension to education at schools. This type of educational technology supports individual teaching that meets educational needs with a high degree of flexibility and reduces time and space requirements. Web tools have greatly influenced the current process of teaching and learning. Virtual laboratories offer a variety of concepts and different components, such as emulators of real laboratories, animations that serve to understand the concept or experiment. Helps reduce bug repetition by alerting users and restoring the experimental scene. Adapting educational systems on a web-based basis requires certain features and different pedagogical methods. Laboratory exercises are essential in teaching computer science. What limits us is the lack of suitable equipment, security problems, insufficient technical support, etc. Virtual Labs are promoted as a visual tool that could bring benefits to students and teachers to reduce workflows, offer varied analyses through various components such as clear interactive animations, simulations.

Animations provide a schematic understanding of the concepts of the experiment in a better way that is not easily communicated by textual or passive illustrations. The visualization techniques used in virtual laboratories allow the student to experience the virtual world. In a traditional lab, users may encounter certain problems, such as limited access to laboratory equipment, lack of equipment, inadequate technical support. We want to focus on the use of virtual lab as a pedagogical method to support the acquisition of practical experience of students.

In addition to animation and simulation for each virtual experiment, the theoretical part explains the theoretical background of the experiment, a procedure details and step by step leads the student. The method sheet is also provided with a set of questions to which the user could respond as part of a laboratory exercise. The electronic system allows users to send their feedback and receive feedback. It is an element that helps us improve the quality of workouts with virtual laboratories.

DISSCUSION ABOUT THE PROFILE ON ICT SUBJECT IN CHINA

As a stand-alone compulsory subject ICT, there has not restrict uniform policy on curriculum standards from government, neither definite regulation about the IT subject, in China. However, related organization carried out some suggestions, or general frame of IT subject. Furthermore, the different provinces, autonomous regions, and municipalities have some autonomies in the main content, the aim, and the amount of the course of IT subject. As you know, there are more than thirty provinces in China, and the difference of different province is very great. So, I give the example—Sichuan province—to discuss the general profile of the IT subject in schools.

First, in primary education, the subject of IT will start at the grade three, in which the age of the pupil is eight or nine. The pupil will learn the subject in four years, with one course per week. The total course will reach 150 proximate during the stage of primary education. The IT teachers can select textbooks for pupils comply with their specific circumstance. There are two modules in the IT subject in primary school, the basic module and the expand module. The basic IT module includes three special contents, namely, hardware & system management, information processing & information presentation, and network & communication. And each special content further includes more concrete and in detail teaching contents, for example, introducing the appearance of computer, the input equipment (e.g., mouse, keyboard), output equipment (e.g., monitor, printer), and the common auxiliary equipment (e.g., loudspeaker, headset, microphone),etc. in the content of hardware (CAET, 2012). In addition, the basic module will be learnt in the grade three and grade four, and divided into 36 units each of which will be taught in each course. Next, The expand module includes two special contents, that is to say, induction algorithm & program design, and beginner of studying robot. The expand module will be studied in the grade five and grade six, and the amount of course is the same as the first module.

Second, in lower secondary education-from grade seven to grade nine, there are approximate 72 courses totally in the IT subject to students with the age of from thirteen to fifteen years old. These courses are arranged usually at the grade seven and grade eight once a week. Moreover, the structure or the frame of the content is the same as the primary's, while with deeper content than that of primary education. Taking the module of algorithm & program design as example, it focuses on direct experience and object teaching in primary education, on the other hand, the IT teachers will pay attention to advanced program and encourage students to try to design or understand the basic structure of program (CAET, 2012). There is not any exam of IT subject in primary education, while a unified examination will be holden at the grade nine in some big city such as Chengdu (the capital of Sichuan province), which has nothing to do with the leaving examination or eleven-plus.

Furthermore in China, in the upper-secondary education, the content and the modules are the same as the primary and lower secondary education, but more abstract and more difficult. The difference is the arrangement of the IT subject which will be taught only at the grade ten with twice a week, approximate 80 courses, totally. Moreover, there is a qualifying examination at the grade eleven, which requires all students reach the same basic level (generally, it is easy). The examination of IT isn't related to the college entrance examination in Sichuan province. On the contrary, the score of the IT exam in some province, such as Zhejiang, Jiangshu province, and Shanghai will be accumulated into the college entrance examination (see Zheng (2017)).

CONCLUSION

There were in Slovakia many national projects for implementing of ICT in education not only in the subject Informatics, but also in other subjects e.g. Infovek, Planéta vedomostí (Planet of knowledge, see Infovek(2017), Planéta vedomostí (2017)). Initiative and projects of this type are important because physical and virtual didactic means play a very important role in today's information society. Their role in the teaching process is based on the fact that in the more diverse ways a person learns, he learns better, faster and remember it for a longer time. While one student only needs a teacher's interpretation to master the lesson, for the other it will not be enough. It will help him if, for example, the subject can be taught, tried, seen, manipulated. Therefore, the teacher must reach out through such means as to make it possible to respect these student differences to make teachers and students more efficient (see Uhlířová, Laitochová (2012)). The teacher is pursuing the means that approximate what is far away, enlarge what is tiny, diminish what is great, slow down what is fast, accelerate what is slow, reveal what is hidden, concretize what is abstract, spark what is past, fix what is fleeting, making it more difficult "(see Bílek (2011)).

The Information Communication Technology (ICT) in Chine conditions is one kind of subject, the same as mathematics, Chinese, English, etc. Generally, ICT, being regarded as a stand alone compulsory subject. The main content in the subject is a bit of similarity, such as the basic skills of operating computer, the application of the Internet, the communication via network, and some simple software. However, the grade of difficulty of the contents is different, and more and more difficult with the increasing of the students' grade. It is fruitful in the future to compare the implementing and content of ICT in Education in different countries.

REFERENCES

Reddi, U. V. (2006). Role of ICTs in Education and Development: Potential, Pitfalls and Challenges. *Learning package on participatory adult learning, documentation and information networking (PALDIN): Participatory lifelong learning and information and communication technologies.* (p. 173-186). New Delhi: Jawaharlal Nehru University. Available from: http://www.unesco.org/educationlaladinl paldin/pdf/course_02.pdf

Štátny vzdelávací program Informatika (Vzdelávacia oblasť: Matematika a práca s informáciami) Príloha ISCED 3A. (2008). Bratislava: Štátny pedagogický ústav. Available from: http://www.statpedu.sk/clanky/statny-vzdelavaci-program-svp-pre-gymnazia/matematika-praca-s-informaciami#overlay-context=clanky/statny-vzdelavaci-program/statny-vzdelavaci-program-pre-gymnazia

Infosoškár, informačný portál pre žiakov. (2017) Revúca: Stredná odborná škola. Available from: http://infososkar.webnode.sk/predmet-informatika/

Infovek (2017). Available from: http://www.zsmrsle.edu.sk/infovek.htm

Uhlířová, M., Laitochová, J. (2012). Pojmová mapa jako most k porozumění matematice. In Uhlířová, M., *Matematika 5 - Acta Universitatis Palackianae Olomucensis*. (p. 302 – 307). Olomouc: Vydavatelství UP. (2012). ISSN 0862-9765.

Planéta vedomostí. (2017). Bratislava: Ministerstvo školstva, vedy, výskumu a športu Slovenskej republiky. Available from: http://planetavedomosti.iedu.sk/

Bílek, M. et all. (2011). *K virtualizaci školních experimentálních činností: reálný a virtuální experiment – možnosti a meze využití jejich kombinace v počáteční přírodovědné výuce*: Hradec Králové: University of Hradec Králové. ISBN 978-80-86771-47-2.

CAET(Chinese Association for Educational Technology) (2012). *The Curriculum Standard of IT in Compulsory Education* [DB/OL]. Bejing: CAET. Available from: http://www.ictedu.cn/TopicNews.aspx?id=147. Retrieved 24 May, 2017.

Turčáni, M., Magdin, M. (2014). Creation of Interactive Teaching Materials Using Adaptive Support Web 2.0. In Milan Turčáni, et al., *DIVAI 2014 – The 10th International Scientific Conference on Distance Learning in Applied Informatics*. (p. 503 - 513). Prague: Wolters Kluwer. ISBN: 978-80-7478-497-2.

Zheng, G. (2017). *The introduction of the frame of IT curriculum in Sichuan province* [DB/OL]. Chengdu: Sichuan Institute of the Educational Research. Available from: http://www.scjks.net/Default.aspx. Retrieved 24 May, 2017.

WIKI IN INFORMATICS TEACHING AT SECONDARY SCHOOL

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Abstract

Education at school should prepare students for their future professional life. That means not only provide the students with knowledge but also develop their various skills and competences. Integrating suitable tools into educational process along with sophisticated learning activities can contribute to the development of important competences required by their future employers and boost student engagement in learning as well. Wiki as one of the Web 2.0 tools is well aligned with the recent educational theories – constructivism, constructionism, connectivism, etc. It promotes collaborative learning and could develop in students several soft skills such as communication skills, critical thinking, time management skill, self-regulated learning, and others. In this article, we describe our experience with using wiki at secondary schools. This tool was employed in informatics teaching in three schools while different scenarios were used. The results of our experiment showed different attitudes of students to the wiki-based activity according to the employed scenario.

Keywords

Wiki, collaborative learning, informatics, high school.

INTRODUCTION

In addition to acquiring knowledge, the school should also provide students with the skills required by their future employers. This means also development of so-called soft skills that include communication skills, ability to cooperate with others and work in teams, ability to give a constructive criticism etc. Therefore, it is desirable for teachers to integrate activities and methods into their teaching that can help students acquire and develop these skills.

As reported in many studies, Web 2.0 technology offers several tools whose integration into education corresponds to recent educational theories such as constructivism, constructionism and connectivism (Homola, Kubincová, 2009; Sandifer, 2013). When employed properly in educational activities they can facilitate the social learning, increase the student engagement and also help to the development of soft skills (Homola, Kubincová, 2009). These technologies include among others wiki – a tool which we decided to use with high school students. In this paper we report on our experiment with wiki-based assignment we have included into informatics classes at three high schools with the aim to support collaborative learning.

WIKI

Wiki is a webpage that allows users to edit its content. Any user can not only add a new post and edit her own post but she can also edit or even delete a post added by someone else. Other useful wiki attributes are the possibility to add discussion to each page, track the wiki page history, link wiki page with hyperlinks creating this way a network of thematically related sites, use categorization, etc. Thanks to these features, wiki is a suitable tool for collaborative work.

Wiki was originally not intended to be used for educational purposes. However, the ease of creating and navigating wiki pages together with benefits the wiki use offers make wiki an educational tool with a great potential. It supports constructivist learning (Parker, Chao, 2007), in which students actively and collectively construct new knowledge and form a common view of the problem.

Wiki can be used in education in a variety of ways, e.g. for annotation of study materials by students, for creating collaborative textbooks or bibliography, as a project diary, as a library of problems related to a given topic, together with the proposed solutions, etc. (Duffy, Bruns, 2006; Gaspar, Santos, 2009; Pérez et al. 2006; Ruth, Houghton, 2009). Even though we have found Slovak and Czech webpages oriented to informatics that use wikis, we have not been able to find any study on wiki use in Slovak or Czech schools.

WIKI AT HIGH SCHOOL – OUR RESEARCH

Participants

The research was conducted at three high schools in cooperation with two teachers, during three months in the school year 2016/2017. Altogether 86 third and fourth year students participated in the experiment. They were divided into three investigated groups. The *group A* consisted of 18 students from the school S1 subdivided into teams of 2-3 people. The *group B* was formed of 21students from the school S2 also subdivided into teams of 2-3. The *group C* was composed of 24 students from the school S2 and 23 students from the school S3. In this group mixed teams of 3-4 students from both schools were created.

Collecting Data

Our research data were collected from a variety of sources. We used the questionnaire method, the interview, we analysed the test results and also the students' posts - wiki pages.

The aim of the *final questionnaire* was to identify students' attitude to the collaborative activity in wiki. The *interview* was used to find out the teachers' views on the activity, the pros and cons of using wiki in school and the teacher's opinion on students' work in it. The *analysis of students' posts* was performed during the whole activity. After each activity round we provided teachers a report on the split of the work among team members, on the visual part of the students' wiki pages, the use of individual wiki components, quoting, and appropriate use of sources.

Wiki-based activity

The task was to create an encyclopaedia of informatics concepts from the thematic unit Computer Networks and Internet. Encyclopaedia should consist of several wiki pages, each of them focused on a specific theme or concept (e.g. software in computer networks, optical fiber, router and modem, etc.). Each wiki page was put together by one team. The whole assignment was worked out in form of homework in several rounds. The aim of this activity was to create a comprehensible learning material of sufficiently high quality, so the students could later use it while preparing for a test or the graduation exam. Wiki employed in this assignment is part of matfyz.sk portal and is based on MediaWiki software.

The activity was performed according to a scenario specific for each monitored group. **Scenario A:** Group A was composed of students from one class who were divided into teams by themselves. The topics for the Encyclopaedia were not explained in advance, they should be studied and processed by students themselves.

Scenario B: The group consisted of students from one class and the teams were created by the teacher. The topics were initially explained in the class and afterwards the students processed them in the wiki for homework. The wiki pages were written in English.

Scenario C: Teams in Group C were created by the teacher with 1-2 students from each of the two participating schools. The subject was explained in the class, and only then the students worked it on in wiki for homework. The students from the school S2 were writing in English and the students from S3 were writing in Slovak.

RESULTS

Particular teams as well as individual students in Group A worked very differently: some of the teams processed their topics well enough, however, certain students did not get involved at all or only at a minimum level, they worked just before or even after the deadline. Also, the functionality offered by wiki has not been used adequately.

Therefore, we were wondering how the students perceived the activity. In the final questionnaire 65% of students felt neutral about the activity, 29% of them did not enjoy it and only 6% enjoyed it (see Fig. 1a)). However, nearly one half of the students claimed that the activity was not demanding or reasonably demanding and for the same percentage the activity was time consuming. Students mostly expressed the satisfaction with their own work in wiki.

In the interview, the teacher explained that students were not used to work on school assignments at home. She would rather place this activity in the in-class teaching in the future. The self-study and writing about unknown topics could also cause the students' displeasure.

The course of activity in groups B and C was more satisfiable than in the group A. Students worked very conscientiously, tried their best and improved every single round. In the first two rounds, there was a problem with quoting, listing references, and adding resources to the images. Gradually, the students' work improved, they quoted, added pictures, and created meaningful content from which they were later able to learn.

The results of the final questionnaire in group B show that 20% of the students liked the activity, 65% of them responded neutrally and 10% did not like it (see Fig. 1b)). For 75% of students the activity was not demanding or moderately demanding and for 10% it was time consuming. Some students complained about difficulty to explain terms that they did not know well. Students mostly did not have a problem working in teams, although some of them were not satisfied with the team mates or their work. 11% stated a communication problem.

Questionnaire results in group C were even better than in group B. Up to 41% of students said they liked the wiki-activity and only 12% did not enjoy it (see Fig. 1c)). 45% of answers were neutral. Since these students worked in a mixed teams with a school and people they did not know before, and even bilingually, we wanted to find out how they perceived the difficulty of this activity. 55% of students reported that it was not demanding or reasonably demanding, others reported a problem to work as a team with other school or to work in a team generally.

Activity in groups B and C came off best. Students worked out their topics conscientiously and included everything required. Sometimes they exceeded the expected quality. According to the teacher, the students prepared a high quality study materials. This was later reflected in the excellent results of the test written by groups B and C after completing this activity.

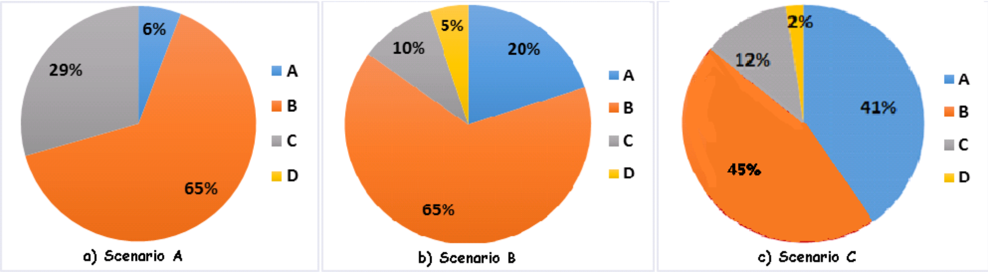

Figure 1: Did you like the wiki-activity? A-Yes, I liked it; B-It was quite OK; C-No, I was tired of it; D-Other

CONCLUSION

Although the collaborative activity in the wiki has produced different results depending on the scenario used, the overall findings are positive. It came out that wiki can be used in high school teaching and also that students are able to work in wiki as a team. Students were able to work on topics without the help of teachers, and the content and quality of the topics often exceeded the required level of their knowledge. Research results further showed that the better scenario is to start this activity only after the relevant topics were explained in class.

Even though the student's views on this activity differ considerably from one another, the teachers can clearly see its benefits. According to one of them, students learned how to collaborate, better search and process information, correctly quote the resources, they improved their writing, etc. Therefore, the results of our research suggest that wiki can be a good tool for collaborative learning already in high school.

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REFERENCES

Duffy, P., Bruns, A. (2006). The use of blogs, wikis and RSS in education: A conversation of possibilities. *Proceedings of the Online Learning and Teaching Conference*, Brisbane Available from: https://eprints.qut.edu.au/5398/

Gaspar, M. I., Santos, M. A. (2009). Learning Communities: way to a new Teaching Model?, *Proceedings of m-ICTE 2009*, Lisbon, Portugal

Homola, M., Kubincová, Z. (2009). Taking advantage of Web 2.0 in organized education (a survey) *Proceedings of ICL 2009*, Villach, Austria

Parker, K. R., Chao, J. T. (2007). Wiki as a teaching tool. *Interdisciplinary journal of knowledge and learning objects*, 3(1), p.57-72.

Pérez, J., Ruiz, M., Gayo, J. (2006). Building a collaborative learning environment based in Wiki. *Current Developments in Technology-Assisted Education*, p. 1413-1416.

Ruth, A., Houghton, L. (2009). The wiki way of learning. *Australasian journal of educational technology*, 25(2)

Sandifer, S. (2013). *Wikis for school leaders: using technology to improve communication and collaboration*. Routledge. ISBN 978-1-317-92756-3.

HOW TO CREATE FEEDBACK IN INTERACTIVE MATHEMATICS LEARNING ENVIRONMENT

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Abstract

Interactive learning materials play an important role in the meaningful use of ICT to support active learning. Immediate feedback in the classroom during the learning process is in most cases provided by the teacher. The importance of feedback even increases when students work with learning materials independently in the classroom or at home. Moreover, ICT tools offer great potential for detecting students' mistakes and guiding students during the analysis and corrections of their solutions. Various forms of feedback should be implemented in interactive learning materials in order to stimulate active learning. The effectiveness of feedback depends on the way how the typical errors of students are taken into account and what way the appropriate hints are implemented in learning. In many available learning materials there is often minimal feedback provided on student´s solution of a certain task. This paper discusses the implementation of various types of feedback in interactive mathematics learning environment. Even though the minimal feedback can stimulate active learning, it may not be sufficient for some types of students who do not think deeply about their methods of problem solving. Higher levels of feedback are characterized by providing comments that depend on student's mistakes and by providing pieces of advice and other helpful additional information that are closely related to the solution of tasks. Demonstrations of the minimal feedback and higher levels of feedback are illustrated in the examples of fractions, percentages and investigation of function dependencies. Interactive learning materials are developed using different ICT tools, such like Geogebra, MS Excel.

Keywords

Mathematics teaching, interactive learning materials, feedback, problem solving.

DESIGN OF FEEDBACK IN INTERACTIVE LEARNING ENVIRONMENT

The policy for mathematics education in Europe described in the publication (EACEA P9 Eurydice, 2011) emphasizes these attributes of the effective methods of mathematics teaching: conceptual understanding and interpretations of representations; learning strategies for investigation and problem solving. Innovative teaching methods in mathematics can be suitably supported by information and communication technologies (ICT). ICT enable students work with diagrams and graphs and develop connections between representations. The computer simulations are designed to facilitate teaching and learning through visualization and interaction with dynamic models (Sarabando, Cravlno and Soares, 2016). Innovative approaches to mathematics teaching are often based on independent inquiry of mathematical relationships.

Inquiry-based learning fosters observations followed by experimentation, modelling, and justification of findings (Hähkiöniemi, 2013).

As surveys in Europe show (EACEA P9 Eurydice, 2011), the use of ICT at home for school relate work is still relatively low. Learning materials, in which are implemented various levels of feedback, can suitably support home learning activities. Implementation of monitoring and managing the learning and evaluation of results into interactive learning materials is essential. In case of incorrect results, feedback can encourage students to rethink their considerations and try to correct procedures for solving tasks. ICT provides possibilities to implement various types of feedback into the learning materials. Feedback in learning materials can be implemented through several ways. McKendree (McKendree, 1990) sees main aim of feedback in interactive learning materials in the following factors: student is called to try again to solve the task, student obtains hints and advices for actions, and student receives short explanation of his /her error.

Conclusions of research performed by Perrenet and Groen (Perrenet and Groen, 1993) show that hints explaining a great part of the problem solution seem to be effective, however the solution was often reached with lack of understanding. Feedback is more effective, if it stimulates concrete action for the required solution method. Identifying a typical student's mistake or misconception would lead to providing a counterexample required next action or an auxiliary question suggesting a solution of the task. The well-known mathematician Polya dealt with problem solving. He emphasized the suitability of using a heuristic strategy based on reformulating the problem (Polya, 1957). If a student cannot solve the original problem, the system may offer a related or reformulated problem which presents a simpler problem for the student or a problem with which he/she should already have experience.

EXAMPLES OF PROVIDING FEEDBACK IN MATHEMATICS LEARNING MATERIALS

When thinking about design and implementation of feedback, it is suitable to focus on the critical parts of learning content. These parts can be source of typical student's errors and misconceptions. In our research we focused on various topics, for example fractions, percentages, functions, probability. The first example is selected from teaching fractions and percentages. Identification of a whole by calculation and comparison parts of whole is source of typical errors in this topic. This type of errors was highlighted in publication focused on evaluating results of upper secondary school examination in mathematics in Czech Republic (Fuchs, 2015).

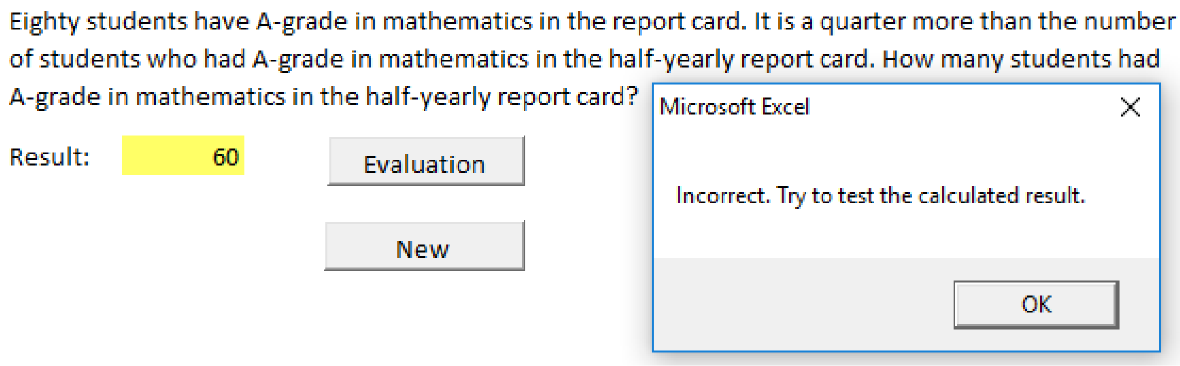

Figure 2: Part of worksheet with task 1

The first example is implemented in spreadsheet environment. Tasks which are the main part of feedback are placed on individual sheets. Figure 1 illustrates task 1 and control button Evaluation to call reaction of the system. Student has to write result to cell with yellow background. Button New erases text field. Typical error is the calculation a quarter of 80 and subtraction of this number from 80. If student writes the incorrect result 60, he obtains the hint displayed in figure 1.

Closing the dialog box with the mentioned hint will cause opening a new sheet containing the reformulated task: *If the number x is increased by a quarter of this number, we get the result 80. Specify the number x.* The assignment of the reformulated task is based on processual model and it suggests to the student how to solve the task. If the student solves the reformulated task correctly, he/she will get an additional task analogous to the first task. Correct solution of the first or the additional task leads to the providing a control task where part of the whole is expressed in percent. Feedback for incorrect results not related to typical error recommends the student to ask for help a teacher.

The second example is implemented in the program Geogebra. Interactive learning environment enables students to investigate linear dependence between quantities. Dynamic environment (see figure 2) provides means for work with various representations: dynamic diagram, table and function rule. The diagram enables students to find a temperature expressed in °F corresponding to the temperature expressed in °C using sliders. Diagrams of this type are a suitable propaedeutic to understand function graphs. Students are asked to enter whole numbers into the table. Specifying of the temperature in the last column requests to discover a linear dependence between temperatures expressed in two scales.

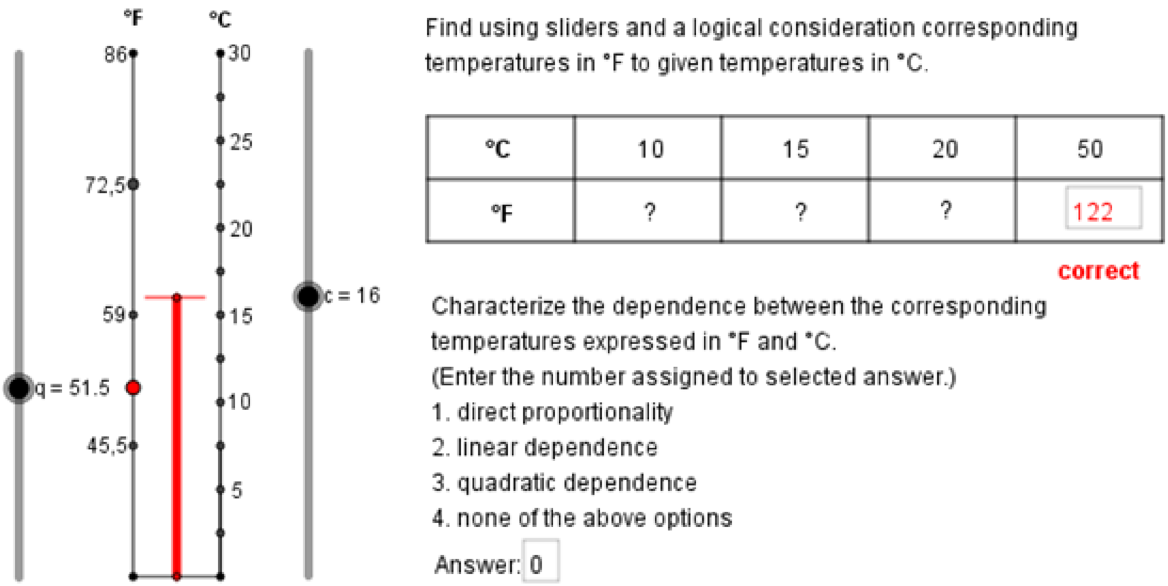

Figure 2: Mathematics learning environment for investigation of the functional dependence

Learning environment provides minimal feedback for written results. If the student is not able to identify a type of dependence between quantities, he can use the auxiliary question attached to a check box. The question directs student's attention on differences between the adjacent values in the table. Selection of the correct answer (2) causes displaying a new task which requires creation of the rule of the investigated linear function.

RESULTS AND DISCUSSION

The described worksheet was used in the first class at high school (20 students). The average success of the students in the first task (see figure 1) was 15 % (3). The reformulated task solved correctly 50 % (10) of the students. The success of the students in the control task focused on percentages was the best (65 %, 13). The results do not point to unambiguous conclusion that the reformulated task helped students to understand incorrect solution of the first task. 20 % (4) of the students solved the reformulated task incorrectly but they solved the control task correctly. It can be assumed that the students already solved this type of tasks on percentages and they remember the algorithm.

We designed feedback in interactive learning materials intuitively based upon our experience as teachers and as problem solvers. Effectiveness of feedback depends on individual students' abilities, problem difficulty and students' experience with the solving selected type of tasks. We assume that providing simpler auxiliary tasks or reformulated tasks is suitable type of feedback stimulating conceptual understanding.

CONCLUSION

Providing effective feedback in an interactive learning environment is a complex problem. It requires a consistent analysis of students' errors and their reasons. Limited possibilities of the use of feedback come to the forefront especially in eliminating misconceptions. Several researches (Perrenet and Groen, 1993) demonstrate that initial student misconceptions are extremely difficult to correct using hints. Increasing feedback efficiency could ensure combining feedback with teacher help.

REFERENCES

Eacea P9 Eurydice. (2011). *Key data on learning and innovation through ICT at school in Europe.* Available from: http://eacea.ec.europa.eu/education/eurydice/documents/key_data_series/129en.pdf

Fuchs, E. (2015). *Současný stav maturity z matematiky.* Available from: https://www.jcmf.cz/sites/default/files/Z-6_AF-LXIV_E-Fuchs_Soucasny_stav_maturity_z_matematiky.pdf

Hähkiöniemi, M. (2013). Teacher's reflections on experimenting with technology-enriched inquiry-based mathematics teaching with a preplanned teaching unit. *Journal of Mathematical Behavior, 32*(3), 295–308.

McKendree, J. (1990). Effective feedback content for tutoring complex skills. *Human-Computer interaction, 5,* 381−413.

Perrenet, J., Groen, W. (1993). A hint is not always a help. *Educational Studies in Mathematics, 25,* 307−329.

Polya, G. (1957). *How to solve it*. Princeton University Press. Available from: https://notendur.hi.is/hei2/teaching/Polya_HowToSolveIt.pdf

Sarabando, C., Cravlno, J., P., Soares, A., A. (2016). Improving student understanding of the concepts of weight and mass with a computer simulation. *Journal of Baltic Science Education, 15*(1), 109−126.

INNOVATIVE TEACHING OF PROGRAMMING IN SECONDARY EDUCATION

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Abstract

This article deals with the teaching of algorithmization and programming on the subject of informatics in secondary education. We introduce new approaches in programming methods for pupils. We further mention a visual environment of language Scratch, Scratch Junior or Kodu. Finally, we describe our experiences with some interactive online applications within the project Code Studio, which include courses suitable for pupils from the primary school. The benefit of using such environments is the development of algorithmic thinking of pupils already in the lower secondary education. It is important to acknowledge future informatics teachers with these trends.

Keywords

Teaching of programming, secondary education, innovative methods, Scratch, Kodu Game, Hour of Code.

INTRODUCTION

Since the school year 2015/2016, the Innovated National Education Program (INEP) has been put into practice for primary and secondary education in Slovakia. A great emphasis in the INEP within the subject Informatics is given to algorithmization and programming (IŠVP, 2015). It is related to the current trends in supporting the development of IT education of young generation and grounding for IT career. These trends also show in the results of the latest survey Informatics education form the point of youth. Students need better preparation for work with ICT in real life (Velšic, 2017).

Informatics teachers on primary schools often have respect for teaching algorithmization and programming. It is also caused by evident disinterest of some pupils in this subject, which may be caused by an inappropriate teaching methodology or by fear of „hard thinking", etc. We see the solutions in creating and promoting appropriate methodical materials and interactive environments, motivating teachers to participate in interesting projects and preparing pupils for the competitions as well as the quality didactic preparation of future IT teachers (Nagyová, 2016, Oujezdský & Nagyová, 2015). Sharing teaching materials, participating in various workshops, or webinars focusing on current topics will support teachers' skills for innovative teaching of algorithmization and programming. It is important to acknowledge future informatics teachers with these trends (Polčin et al., 2016).

Nowadays, we are seeing a slight increase in the number of lessons devoted to programming at the elementary schools in Slovakia. Teachers are gradually acquainted with new learning methods and welcome all methodological assistance (Šnajder & Guniš, 2016). Within our research for new teaching methods for future informatics teachers with support of the project KEGA Innovative methods in teaching Informatics in secondary education, we are looking for suitable programs for innovative informatics teaching with mobile devices and online applications.

PROGRAMMING IN SCRATCH AND SCRATCH JUNIOR

In the subject of didactics of informatics and in final work of students, future teachers of informatics at the Faculty of Education of the Catholic University are lead to the preparation of innovative methodologies and teaching aids. With some work, students have successfully joined the student's scientific field. During the Czech-Slovak Scientific Conference in Didactics of Informatics 2013, the work Creative programming in Scratch was successful (Hruboš, 2013).

As stated by Šnajder (2014), in the programming language Scratch is a great space for creating multimedia-attractive applications. Scratch Junior is a new program based on Scratch. ScratchJr is a visual programming language where pupils can also program using the system of drag and drop. The advantage of this programming language is in its simplicity. It is a suitable programming background for children in pre-school and young school age (5-7 years). The environment allows children to explore programming principles. All the controls that students use when creating their program are commands that have a colorful layout with large buttons and are easy to use with a finger on the tablet screen. Commands are assigned to the selected objects by dragging commands to the programming area (Fig. 1).

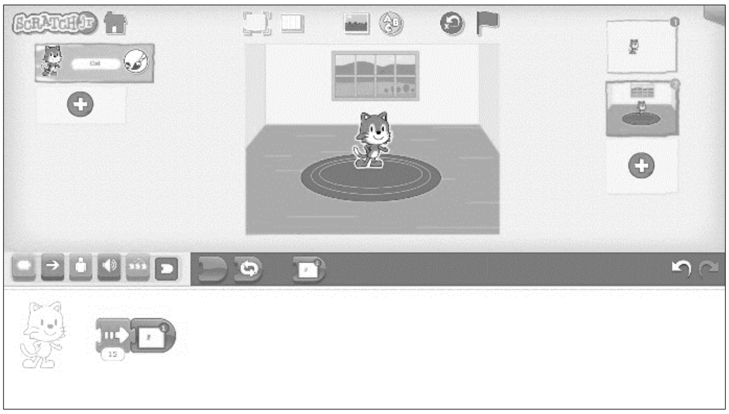

Figure 3: Environment of the program ScratchJr

ScratchJr is available as a free app for iPad and Android tablets. ScratchJr can also be run under the Android OS NOX emulator on a desktop computer. On the homepage http://scratchjr.org, methodological materials and sample worksheets are available for teachers. Activities can be focused on work with graphics and animations, the development of reading and mathematical literacy, and the creation of simple children's games. The tutorials were created, which offer basic knowledge of the ScratchJr application. They are used to familiarize with the various features that the program contains. There is a worksheet with an illustrative video tutorial that introduces the ScratchJr environment and its core functions to the pupils. Video tutorials are available at http://tablet.jecool.net/ (Majherová et al., 2017).

ONLINE ACTIVITIES FOR PROGRAMMING

Online apps can inspire teachers when teaching algorithmization and programming. Under the project Hour of Code, there is large selection of interactive courses divided according to class. Themes of these courses are motivating for pupils, as they are based on popular movie stories, Frozen, Star Wars and so on (Fig. 2). The page also contains tutorials for the teacher (Hour of code, 2016).

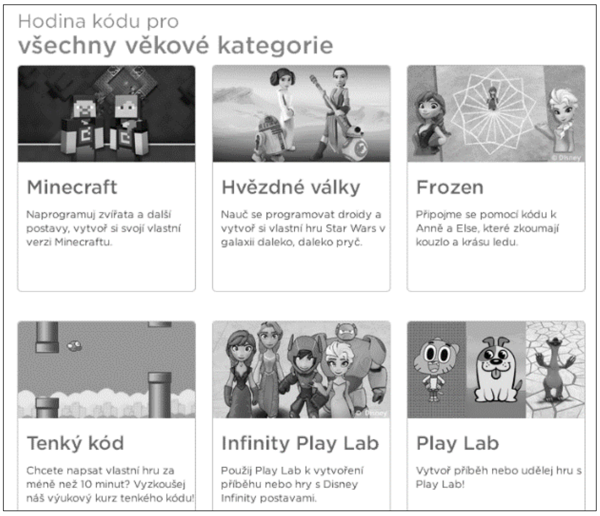

Figure 2: Activities the Hour of Code

During the week from 5 to 9 December 2016, students of the Informatics Teaching at Faculty of Education at Catholic University in Ružomberok realized within the framework of pedagogical practice some activities of the Hour of Code at two elementary schools in Ružomberok. Pupils worked on tablets or desktop computers. From students' observations, we can say that 4th - 5th grade pupils have mastered the activities of Minecraft (level for 2nd grade and above). Pupils had difficulty coding at the course Frozen (introduction to turtle graphics) when they needed the knowledge of the angles they will get in the 6th grade. Pupils also practiced loops because they appeared in most of the tasks. They had to deal with how many times the orders had to be repeated. Lessons of Hour of Code are specially designed to enable pupils to understand the basics of programming using visual programming. Pupil who has successfully completed at least one of the lessons has received an International Code Exam Certificate (Jančová, 2017).

Another option to involve pupils in interactive online programming courses is at website code.org where many interesting projects are available (Code Studio, 2017). Also environment GalaxyCodr offers an exciting opportunity to visualize the basics of programming. It is a didactic software - an educational game for the development of programming basics, which, besides the skill of creating custom software, develops creative, logical and algorithmic thinking in the child. The environment offers visual programming, commands are block-shaped, and the code itself is comprised of drag and drop. The pupils are programming using the game (fig. 3).

Figure 3: GalaxyCodr

PROGRAMMING IN KODU

Another suitable environment for the teaching of programming in elementary school is the environment Kodu. Kodu is a free program that allows you to create games on the computer. It uses a simple visual programming language. It includes own library of objects and allows the easy visual programming (Fowler et al., 2012). The pupils present their creativity to solve problems and at the same time they program in a simple form. Kodu contains interesting graphical environment and the programming in it does not require the knowledge of programming languages and the creator monitors his progress in real time. The development environment is designed for educational purposes and uses a library of 3D models. The code is composed of the commands for the object. The toolbar includes the creation of buildings, roads and surfaces. It contains a large library of the materials. The pupils can change the sky, lighting, camera settings, transparency, wind and other effects in the world. They determine how the game begins for instance: the name of the world, description of the world, countdown. In addition to setting the world it is possible to set each object separately (Kodu, 2017).

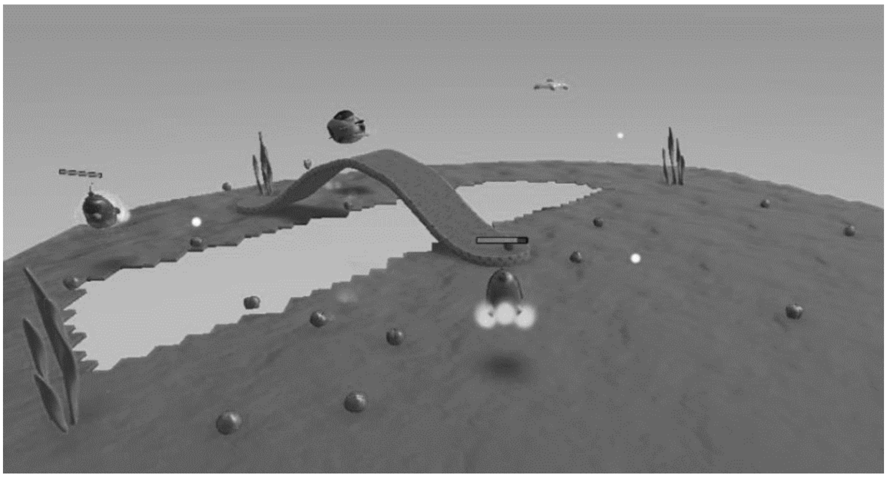

Figure 4: Sample of game in Kodu

Programming in the Kodu environment was verified as part of a pedagogical practice in the 5th year of the Elementary School in Rajec. The teacher prepared five lessons to verify the methodology. When working with the Kodu program in the school classroom, there was no bigger problem, but the program responded with a delay on some computers with a less powerful graphic card. The pupils were interested in the new subject and were working with enthusiasm in the software, mainly thanks to 3D graphic visualization. The great motivation was to create and play their own computer game (Jasenovec, 2017). Some differences in the levels of pupils´ work occurred, for example in the time required to control the new environment and intuition when working with the program, as well as the algorithmic thinking in solving the assigned tasks. Some pupils were lost in the new software, some just rewrote the code according to the pattern and were satisfied with how the game worked.

CONCLUSION

In our paper we described using of different educational environments for teaching of algorithmization and programming in the lower level of secondary education. If we want the student learns constructively let's project the lessons so that pupils are stimulated by the appropriate motivation (Gunčaga et al., 2015). We can create sufficient space for experimentation and collecting own experiences. The appropriate roles in the zone of the following evolution move the pupils' knowledge further. We include to the lessons playful and creative activities to maintain positive communication climate.

The teacher is not only instructor in the computer science education, but more a manager and a moderator of pupils. He must prepare activities in which the educational software and its programming aspects can support construction of new knowledge for every pupil. Solving logical problems helps to develop logical and algorithmic thinking by pupils.

In our project we will create the various tasks with benefits of visualization of algorithms, interactivity and a higher motivation of the pupils at different levels of difficulty. Our pedagogical experiences have shown that this kind of teaching is appropriate for pupils and it supports and develops their creativity.

ACKNOWLEDGEMENTS

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REFERENCES

Code Studio. Available from: https://studio.code.org/

Fowler, A., Fristce, T., & MacLauren, M. (2012). Kodu Game Lab: a programming environment. In *The Computer Games Journal* 1(1), 17-28.

GalaxyCodr. Available from: http://www.galaxycodr.com/

Gunčaga, J., Janiga, R. & Žilková, K. (2015). Supporting of simulation and visualization through ICT in the educational process. In *Information and Communication Technology in Education 2015*. pp. 169-180. Ostrava: University of Ostrava.

Hour of Code. Available from: https://hourofcode.com

Hruboš, J. (2013). *Tvorivé programovanie v jazyku Scratch – metodika*. Práca Česko-slovenskej ŠVK v didaktike informatiky. Bratislava: FMFI, UK.

IŠVP Inovovaný Štátny vzdelávací program. Innovated National Education Programme [online]. [cit. 2017-01-02]. Available from: <http://www.statpedu.sk/sk/Inovovany-Statny-vzdelavaci-program.alej>.

Jasenovec, M. (2017). *Tvorba úloh v detskom programovacom jazyku*. Diploma thesis. Ružomberok: Catholic University 2017.

Jančová, L. (2017). *Kognitívne aspekty výučby programovania na ZŠ.* Diploma thesis. Ružomberok: Catholic University 2017.

Majherová, J. (2015). Inovácie kurikula v informatike na ZŠ. In *DidInfo 2015.* s. 191. Banská Bystrica: Univerzita Mateja Bela.

Majherová, J., Petrušková, H., & Valuška, P. (2017). Interaktívne učebné materiály vo vyučovaní algoritmizácie (Interactive educational materials for teaching programming). In *DidInfo 2017.* s. 101-104. Banská Bystrica: Univerzita Mateja Bela.

Nagyová, I. (2016). Constructivism in teaching of basic computer skills. In *Information and Communication Technology in Education 2016*. pp. 124-132. Ostrava: University of Ostrava.

Oujezdský, A., & Nagyová, I. (2015). Developing technical skills of pupils in primary and secondary schools. In *Information and Communication Technology in Education 2015*. pp. 182-187. Ostrava: University of Ostrava.

Polčin, D., Petrušková, H., & Stando, J. (2016). Support and Improvement of the Educational Process in Regional Education in Slovakia Through Tablet Classrooms. In *The Third International Conference on Computer Science, Computer Engineering, and Education Technologies.* pp. 71-78. Łodz: Łodz University of Technology.

ScratchJr. Available from https://www.scratchjr.org/teach.html

Šnajder, Ľ., & Guniš, J. (2016). Analysis of results in inquiry based informatics education of selected topics. In *Information and Communication Technology in Education 2016*. pp. 169-180. Ostrava: University of Ostrava.

Šnajder, Ľ. (2014). Scratch as a glue for funny programming, curiosity and music creation. In *Information and Communication Technology in Education 2015*. pp. 282-236. Ostrava: University of Ostrava.

Velšic, M. (2017). Informatické vzdelávanie optikou mladých. Bratislava: Inštitút pre veřejné otázky IVO.

Trend Analysis of the Educational Choice of University Entrants as Tool to Improve the Quality of Educational Service

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Abstract

The problem of improving educational mechanisms is emerging as one of the most urgent, because the quality of education in today's conditions determines the competitiveness of both the university itself and the national education system as a whole. In the national high school the sociological assessment behind functioning of the higher educational institution is becoming topical with the need to improve educational services and the general verification of the conformity of educational services to the needs of consumers, the state and society. In order to improve educational services it is necessary to study and develop technologies of sociological analysis and forecasting the development of educational space. The paper discusses the main European standards and Guidelines for quality assurance in higher education (ESG). It is argued that analyzing students' expectations about future university can be one of the tools to improve the quality of education assessment, in particular, the method of trend analysis, which is an analytical and mathematical technique that allows to record slow changes in the parameters of the investigated process.

Keywords

higher education, educational quality, sociological analysis, students' motivation, trend analysis

INTRODUCTION

In the conditions of development of modern Ukrainian society the questions related to educational space are extraordinarily actual. It is education that gives an opportunity for development and progress of personality and the quality of education in modern terms determines the competitiveness of university and national system of education on the whole. Mirroring the European experience of quality management of education a sociological estimation and examination of functioning of University teaching has gained importance with the aim of preventing off-grade services and general verification of accordance of educational services to the demand of consumers, state and society. Coming from it, it is becoming urgent to develop methodologies and measures to make complex sociological estimation of activity of university with the aim of upgrading educational services.

STATEMENT OF THE PROBLEM

The use of information technologies in the field of education, aspiration of consumers of educational services to get complete and clear state information functioning and development of educational establishments, adjusting of processes of algorithmization of administrative activity was entailed active research of the integrated functions of management, among that, - quality management of educational services on the basis of information technologies. In particular the special weight is acquired by determination of main instruments of improvement in educational services - from government control to the individual professional intentions of consumers of the educational programs (Kulik, 2015). To achieve this goal it is necessary to study and develop the technologies of sociological analytic geometry and forecasting of developments in educational space taking into account the upgrading of the offered product (knowledge, skills, practical abilities).

RELATED WORK

Researches of problems of education are related to the names of many prominent scientists, including the classics of sociology - M. Veber, E. Durkgaim, O. Kont, K. Manheim, P. Sorokin and others. Civilization conditionality of changes in the system of education was the object of previous research by foreign scholars – Z. Bauman, D. Bell, E. Vallershtain, F. Kumbs, O. Toffler.

The classics of structural-functional approach (R. Merton, T. Parsons) examined methodological principles of research into structure of higher education. Their tradition was continued by structuralists, neomarksizmists (in particular P. Burdie, G. Gintis, R. Collins, D. Coulman). K. Janks, D. Risman laid the foundations of education system as "hub" that builds modern society.

Considerable advance in research of problems of higher education was made by sound research in the field of philosophy of education, sociology of education, pedagogics of higher school, namely by the Ukrainian researchers: V. Andrushenko, V. Arbenina, V. Astakhova, V. Bakirov, V. Viktorov, L. Garasina, I. Kovalova, K. Korsak, S. Plaksiy, O. Podolska, L. Sokuranska, S. Schudlo and others.

STATEMENT OF RESEARCH RESULTS

It is worth mentioning, that in the conditions of dynamic reformation of the Ukrainian system of education a starting point is creating the model of home education adequate to the requirements and standards of world tendencies. In turn, of special value are European technologies of organization of educational space. The European system of quality management of education is based on the European standards and recommendations (ESG) that in turn are based on the following basic principles: personal interest of students, employers and also societies on the whole in high quality of higher education; key importance of autonomy of establishments and institutions, with deep awareness of that an autonomy bears within itself serious responsibility; the system of external quality assessment must fulfill its aim and not complicate the work of educational establishments more than it is necessary for implementation of the system's tasks (Enqa, 2015).

Leaning on an offer methodology of L. Teveno, well-known the Ukrainian researcher of education S. Schudlo distinguishes a few orders in the estimation of quality of education.

Civil order. In this case the source of criteria to estimate the quality of education is collective interest. The criteria of quality are determined by interests of society, appeal to the "eternal values". A legitimate model of quality of education is a model of socialization of individual.

Market order. The source of criteria of estimation is private (business) interest. The criterion of quality contacts with satisfaction of certain consumer. A legitimate model of education is a grant of service, where student and/or an employer appears in a role of client.

Professional order. In such order the source of criteria is presented by professional community. The criterion of estimation is a conclusion of expert about accordance of quality of object to the certain professional standards. A corresponding model of education is an appropriation of professional knowledge, abilities, skills, competenses.

Industrial order. Standard criteria and requirements are the source of criteria of quality. In order to estimate quality, the subject should not necessarily be an expert. The criterion of quality certifies accordance of process and result to certain standards and norms.

The specific feature of the described model is that for its realization there has to be previous work on development of criteria and indicators. The legitimate model of education is an appropriation of certain standard set of knowledge and abilities (Schudlo, 2016).

In research of quality of higher education the Ukrainian scientists rely upon the fact that quality of education characterizes the degree of accordance of education to the public queries addressed to it. Various demands of different subjects of educational environment are actualized in the same society and are formed by it. Thus, society sets specific reference-points correlated with education.

In this context we will stress that we suggest to interpret the term “quality of education” in two ways: as accordance, firstly, to the standards of education, secondly, to the queries of consumers of educational services. Quality in first case is interpreted from the point of view of producer, conforming of products or services to the requirements, standards or certification. The basic "producer" of educational services is the state through the network of educational establishments, and quality of education is estimated through the state mechanisms of licensing and accreditation.

The second accordance is quality from the point of view of consumer. The community of consumers of higher education is wide enough. Students and their parents, potential employers belong to it, society on the whole (Schudlo, 2016).

Today's realities reveal the problem, when student, making a mistake when choosing his potential university and degree, often can not change future speciality and is forced to adapt to a "sad" prospect of working in the future at undesirable work, to miss vocation. In an eventual result all of it results in absence of motivation to the studies, poor results of preparation within the framework of educational process, and, eventually, poor qualification at graduation, when the students do not want to in their field, which reduces general prestige of educational establishment (Kudirko, 2016).

Thus, we suggest to estimate entrants’ expectations in relation to studies in the university as one of instruments of upgrading quality of higher education. Special attention should be given students’ motivation for entering the university and factors of influence on choosing an educational establishment. In this context it is possible to use the methodology of trends analysis.

Trend analysis is an analytical and mathematical technique that allows to record slow changes in the parameters of the investigated process. In studying the trend, two tasks are solved: 1) they analyze the influence of factors on the resultant indicator (factor analysis in SPSS: z-transformation, Pearson' correlation coefficients, orthogonal rotation according to varimax method); 2) method of extrapolation helps predict the behavior of the resulting indicator in the next moments of time. In studying the trend they apply methods of moving average, alignment at several points, analytical alignment, the special case of which is the regression method, etc. The development of mathematical model of the trend allows to solve both problems: to conduct analysis and predict the dynamics of the resulting indicator. However, the basis of the model should be presented by some logical construction and its (model) must necessarily be checked for adequacy. A model is considered adequate if the determination coefficient (squared coefficient of correlation) is above 0.5.

The vertical analysis of trend allows to define specific power of influence of every factor on a professional choice. The horizontal analysis of trends provides for the definition of dynamics in indexes of influence on an educational choice. By means of these methodologies the results of the sociological researches conducted two years in succession were analysed. Research was devoted to the study of professional choice of university entrants of Dnipro city in 2016 and 2017. Research is undertaken by the department of sociology of the Oles Honchar Dnipropetrovsk national university.

The results received allowed to educe trends in orientations in relation to the choice of future professions, sentinel changes in the personal interest by tendencies in educational space, main differentiative factors of choice of university. Accordingly the obtained data give an opportunity to study quality of education based on opinions and expectations of direct consumers, and also effeciency of every separate university in relation to upgrading educational services. Among the instruments of analysis there were applied tools of specialized programs of *SPSS* and technologies of *Googletrend*. It allowed to connect the level of electronic information environment and ontological space of the problem.

REFERENCES

Gorbov, V. (2016). Prospects of sociological estimation of quality educational services: methodical recommendations. *Studentcentrizm in the system of providing of quality of education in an economic university, (s.33-34).*

Kulik, O. (2015). Choice of system of indicators for estimation of quality of grant of educational services by educational establishments.*Scientific Journal «ScienceRise», №7/1(12), 47-53.*

Standards and Guidelines for Quality Assurance in the European Higher Education Area (2015). Available at: http://www.enqa.net/bologna.lasso. Accessed 11 March 2015.

Schudlo, S. (2016). Mechanisms of forming of social conventions are in higher education as condition of providing of her quality. *S.P.A.C.E., № 1, 31-37.*

Kudirko, O. (2016). The choice of profession is choice of course of life: agitation work with potential entrants. *Studentcentrizm in the system of providing of quality of education in an economic university, (s.99-100).*

ADAPTIVE STUDY MATERIAL IN MOODLE LMS WITH GAMIFICATION FEATURES

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Abstract

This paper is aimed at creating an adaptive study material in the Moodle LMS. The study material comes in four different variants – verbal, visual, auditive and kinaesthetic – based on students' sensory preferences. The four variants have identical content and deal with the same curriculum. Before the start of instruction, students fill out a questionnaire, which will determine their sensory type. Based on their determined sensory type, students will then be divided into groups (corresponding to their sensory variants).

Moreover, the study material contains gamification features which motivate students to study more. Badges have been created which students collect for completing study tasks, such as submitting homework, posting a comment on a discussion board or passing a test. Levels are another gamification feature – based on their study results and time spent in the course, students improve their level.

Keywords

Multimedia, education, E-learning, Adaptive study material, LMS, Moodle, Gamification, TelePort, Hyperspace

INTRODUCTION

For a number of years, the research focus of the Department of Information and Communication Technologies at the Pedagogical Faculty of the University of Ostrava has been on creating multimedia-based textbooks. Such study materials are used in part-time study programs. In recent years, a number of research projects aimed at creating and implementing adaptive multimedia textbooks have been conducted. Such textbooks are not only a source of information for students, but can also adapt to the student's characteristics and provide them with optimal study materials. (Kostolányová, 2012)

A questionnaire is used to determine students' sensory preferences, which are used as the basis for determining their preferred learning style. There are four types of sensory preference – verbal, auditive, visual and kinaesthetic. Based on their sensory preference, students are presented with an appropriate variant of the adaptive multimedia textbook. (Takács, 2014)

It is clear that adaptive multimedia textbooks need to come in at least 4 variants which cover the same curriculum but present it differently, reflecting the particular sensory preference. (Drápela, 2014)

THEORETICAL BASES

J. Mareš (1998), a scholar who specializes in learning styles, characterizes them as learning techniques which an individual uses in the majority of pedagogy-related situations at a particular period in life. To some extent, they are independent of learning content.

The aforementioned sensory preferences fall under learning styles. They influence the way in which an individual acquires and processes information through their senses. Healthy individuals, who are able to perceive stimuli through all the senses, use the senses differently based on their sensory preference.

In the first year of the project "Analysis of Learning Style Characteristics and Their Use in Electronic Instruction", a part of an adaptive multimedia textbook was created. Created in the adaptive Barborka LMS, the textbook was tested in high school, grammar school and university instruction. Approximately 100 students participated in the pedagogical experiment. (Pastyřík, 2016)

In the first stage of the project, students' preferred learning style was determined. Afterward, students took a pretest that tested their knowledge of the curriculum. In the next stage, the instruction took place, followed by a posttest. At the conclusion of the experiment, the pretest and posttest results were evaluated (and also examined with regard to the type of school). Finally, students filled out evaluation questionnaires which evaluated not only the quality of instruction and the content of study materials, but also their form (adaptive textbooks in the Barborka LMS).

The adaptive multimedia textbook was updated to reflect the results of the pedagogical experiment and evaluation questionnaire, respectively.

MATERIALS & METHODS

Following the previous research, the adaptive multimedia textbook (Oujezdský, 2014) was updated and re-created in the Moodle LMS. Not only does the Moodle LMS contain a number of useful tools (glossary of terms, discussion board, correspondence task, tests), but also divides students into groups, with each group being presented with different variants of the study materials which reflect their sensory preference. (Fleming, 2012)

The Moodle LMS allows for study materials to be created in different forms. For example, it is possible to upload a study material as a text document, create a website or create a special element which is called "Lecture", which presents a series of interconnected websites. It can contain both study materials and revision questions. The main advantage of "Lecture" is branching, i.e. being guided through the lecture, the student can visit websites containing additional study materials. Based on the student's answers, the lecture can either continue (the correct answer) or take the student back to the curriculum or let them answer the question one more time (the incorrect answer).

RESULTS

The adaptive multimedia textbook consists of a general part, which is intended for all students, and a lecture, which comes in four variants. Firstly, students' preferred learning style is determined through a questionnaire. Then students are divided into groups. Even though the lectures for each group come in different forms, they cover the same curriculum.

The general part includes the pretest (which tests students' knowledge of the curriculum), the discussion board, the glossary of terms, the course objectives, the correspondence task and the posttest. Following the "lecture", students' posttest results are analyzed to determine whether or not there has been an improvement in knowledge.

The topic of the "lecture" is computer buses. The lecture is divided into a number of chapters, with each chapter covering a comprehensive part of the curriculum, i.e. the definition of a computer bus, the division of computer buses, the basic parameters, etc.

In order to motivate students to study, a motivational video was created which – in a funny way – stresses the importance of computer buses and tries to explain why it is important to have practical knowledge of them.

Lecture variants

Four variants (in the form of four "lectures") of the study material were created. All four variants contain the same information, which is presented differently.

Aside from general information, the lectures also contain additional information (such facts provide additional knowledge, but are not included in tests or revision tasks). However, those interesting facts come in the form of text and additional images and are identical in all four lecture variants. (Zlámalová, 2008)

Verbal variant

This variant contains text information and images. Since the curriculum is so difficult that it could not be taught without the images, their presence is necessary.

Auditive variant

Contains the same curriculum as the verbal variant. However, in this variant the texts come in the form of audio recordings. Apart from audio recordings, this variant also contains images.

Visual variant

In this variant, the curriculum comes in the form of mind maps and animated presentations which should make it easier for the visual students to remember the information.

Kinaesthetic variant

This variant contains video recordings with the teacher explaining the curriculum. Moreover, images and additional text information are also displayed on the virtual screen. (Bijnens, 2006) The video recording can be seen in Figure 1.

Figure 1: Video recording in a lecture

Gamification features

Using gamification features in a course is a modern way to make instruction more attractive for students. It means that similar features to those used in computer games are used in instruction. The following are the basic gamification features used in the course: (Taspinar, 2016)

- Levels – students improve their level by meeting requirements.
- Badges – students can collect badges for completing particular assignments.
- Completion indicator – during the lectures, students can see how far in the lecture they are.

Levels

Based on the number of correct answers, time spent in the course, number of mouse clicks or posting comments on a discussion board, students can improve their level. A gamification plugin (which needs to be installed) is responsible for levels in the Moodle LMS. When the plugin is installed, one can select activities for which students earn points. Each level is achieved by accumulating a certain amount of points. The number of points earned for particular activities (the mouse click, the correct answer, posting a comment on a discussion board, etc.) is set by the course administrator.

The created Moodle LMS course contained ten levels, each of which had its own graphic symbol. The student is notified when they reach the next level. In order for students to try harder, the amount of points needed to achieve the next level increases with each level. Figure 2 shows graphic representation of individual levels.

Figure 2: Graphic representation of individual levels

During the testing of the course, the amount of points earned for individual activities was set to favor the students who spend the most time in the course, complete all of its parts and actively participate in discussions (those students achieved the highest level). One should be careful when setting the amount of points earned so as to avoid less active students achieving the highest level or highly active students (who not only study, but also actively participate in other course activities) having no chance of achieving the highest level. Therefore, the criteria and amount of points necessary to advance to the next level need to be set before the course can be tested by students.

Moreover, the overall ranking (students are ranked by the amount of achieved levels) is available for all students to see.

Badges

Badges are another gamification feature. Students collect them for completing course activities, such as posting comments on a discussion board, taking a test or submitting a correspondence task. In this particular course, students can collect as many as eight badges. The same graphic style was used for the individual badges (different colors and graphic elements were used). The graphic form of the badges can be seen in Figure 3.

Figure 3: Graphic form of selected badges

The badges the student has collected can be seen (by anyone) in their profile.

Completion indicator

The completion indicator which tells students how far in the lecture they are is the last gamification feature. Therefore, students always know how much coursework they have left to finish. Moreover, on the next startup, they can return to the exact place where they stopped the last time.

DISCUSSION

The adaptive multimedia textbook created in the Moodle LMS will be implemented into instruction at the Department of Information and Communication Technologies in the winter semester of the following academic year. Moreover, it will also be tested in a grammar school in the first half of the new academic year.

Even though the adaptive multimedia textbook is an updated version of the original adaptive textbook created in the Barborka LMS, the update is so significant that it is a brand new textbook (with original content). Moreover, the new textbook contains gamification features which should motivate students to study more.

CONCLUSION

The paper is aimed at the creation of adaptive multimedia textbook in the Moodle LMS. This textbook is an updated version of the original adaptive textbook created in the Barborka LMS. It was created within the scope of the project "Analysis of Learning Style Characteristics and Their Use in Electronic Instruction". The study material was updated and partly modified. Moreover, new features were added, such as mind maps, animated presentations and video recordings.

The textbook covers one comprehensive instructional unit, i.e. computer buses. The study material comes in four variants, reflecting students' sensory preferences. A questionnaire is used to determine students' sensory preferences. Based on their sensory preference, students are presented with an appropriate variant of the adaptive multimedia textbook.

Since the textbook was created in the Moodle LMS, tools available in this environment were used – a pretest, a posttest and a discussion board were created and a glossary of terms and motivational video were added.

Gamification features were added to motivate students to study more. When going through the textbook, students collect points and achieve new levels, collect badges for completing particular course activities and are informed by the completion indicator how much coursework they have left to finish.

The created adaptive multimedia textbook was presented to students who will be using it as a learning tool. Within the scope of the project "Analysis of Learning Style Characteristics and Their Use in Electronic Instruction", the textbook will be used in a pedagogical experiment and other research activities (with regard to the project objectives).

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REFERENCES

BIJNENS, M, VANBUEL, M., 2006. *Handbook on digital video and audio in education*. VideoAktiv Project, Netherlands, 2006.

DRÁPELA, R., 2014. *Learning management system adapted to student's learning style*. Ostrava, 2014. Diploma thesis. VŠB – Technical University of Ostrava.

FLEMING, N. D., 2012. *Facts, fallacies and myths: VARK and learning preferences*. 2012. Available as PDF at: http://vark-learn.com/wp-content/uploads/2014/08/Some-Facts-About-VARK.pdf

KOSTOLANYOVA, K. *Theory of adaptive e-learning*, Ostrava: University of Ostrava, 2012, ISBN: 978-80-7464-014-8 MAREŠ, J. *Learning styles of pupils and students*. Prague: Portal, 1998. p. 240. ISBN 80-7178-246-1.

OUJEZDSKÝ, A., 2014. *Creation of educational video tutorials and their use in education.* ICTE Journal. 2014, ed. 2014, pp. 28-39.

PASTYŘÍK, Milan, Petr ŠKUTA, Ondřej TAKÁCS a Aleš OUJEZDSKÝ. *Variant texts according to types of sensory perception.* ICTE Journal. 2016, 5. DOI: 10.1515/ijicte-2016-0012. ISSN 1805-3726.

TASPINAR, Bahar; Werner, SCHMIDT. *Gamification in Education: A Board Game Approach to Knowledge Acquisition*. International Conference on Knowledge Management, 2016, DOI: 10.1016/j.procs.2016.09.104.

TAKÁCS, O., 2014. *Automatized management of adaptive education in e-learning based on student's learning styles*. Ostrava, 2014. Dissertation. VŠB – Technical University of Ostrava.

ZLÁMALOVÁ, H., 2008. *Distance Learning and eLearning: Textbook for distance learning*. Prague: University of Jan Amos Komenský, Prague, 2008. ISBN 978-80-86723-56-3.

FLIPPED LEARNING: LEARNING BASED ON STUDENTS EXPERIENCE

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Abstract

The article devoted to the questions of implementing the technology of "flipped" learning into the practice of higher education in Ukraine and Poland: it is defined the principles of technology development and it is determined the need for information support; it is offered online platforms and resources; it is developed recommendations on resource selection based on analysis of the needs of modern students in the process of implementation of the proposed model. Problem of Research. The virtual learning environment of modern educational institution not always take accounts a learning needs of its students, content and technology that they use in creating and maintaining their own personal educational environments. Research question: Or the quality of the virtual learning environment of modern educational institution must be based on learning needs of its students, content and technology? During research has been identify the tools and technologies that students prefer during their preparation for classes and presenting results of their own activities.

Keywords

Information and educational environment, experience, flipped classroom, Personal Learning Environment, electronical resources.

INTRODUCTION

Analysis of the impact of macro, mezo and micro trends, design of educational environments and models are the subject of research scientists and educators.

TASKS OF MODERN HIGHER EDUCATION

Observations show (fig. 1) that the global context in which learning takes place varies in a systematic way, and it is influenced by many factors (Miller, Shapiro, Hilding-Hamann, 2008).

Higher education differs from primary and secondary education not only by the age and level of students' knowledge, but also by the fact that within its system new knowledge in the cultural, social and economic spheres of society are created and used.

In addition, increasing the role of learning in the global knowledge society is creating new economic opportunities, in particular for the provision of non-profit educational services, which, in turn, requires the provision of quality and efficiency (ISO Standard, 2010).

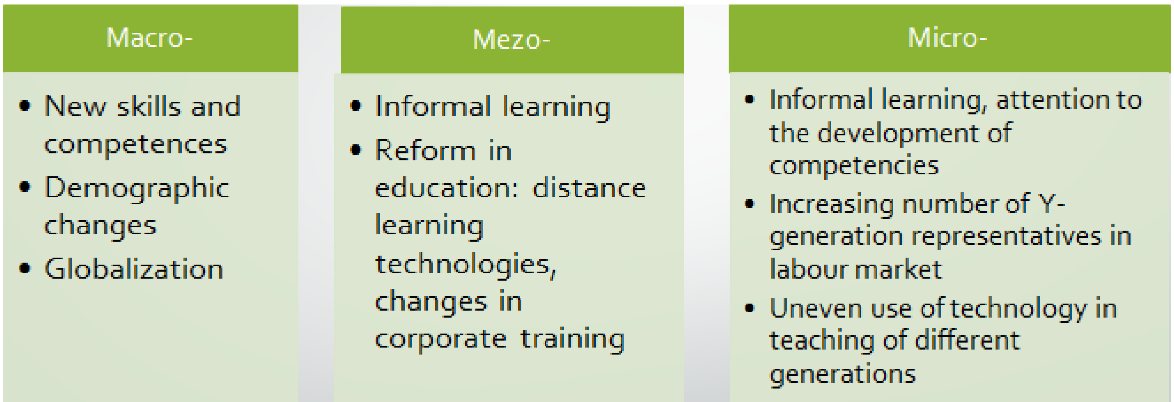

Figure 1. Trends in Education (Source: Own work based on Miller, Shapiro and Hilding-Hamann, 2008)

For learning of new information and communication technologies and their integration into the educational, economic and political processes, a high level of motivation and training of their members is required. Dynamic of described processes requires flexibility of modern universities to ensure the implementation of the demands of society (and sometimes - their prediction) through the introduction of innovative teaching and IC-technologies in the educational process and scientific activities.

FLIPPED LEARNING: AN ANALYSIS OF THE EXPERIENCE

There are different ways to implement flipped learning, but they all are based on one basic principle: the direct study of the theoretical material takes place in a distant way, and the critical discussion of the learned material, practice and applying takes place in the audience (Marshall, 2013). Thus, students perform tasks that require more complex cognitive activity in an audience under the direction of a teacher. At the same time, the role of the teacher is also changing - he becomes a facilitator, coach, and consultant.
The "flipped" learning model (Figure 1) refers to the blended learning technology (El-Mowafy, Kuhn & Snow, 2013), which can be used both for distance learning and for the full-time studying support, and involves usage of distributed information and educational resources with the use of elements of asynchronous and synchronous learning in combination with active learning methods.
The analysis of publications concerning the implementation of the model of "flipped" learning is the basis for formulating the following assumptions:

- Proactivity of the students is one of the factors of learning effectiveness. The probability of personal activity of the students is increased in the case of involving students in empirical activities, based on their experience, taking into account educational needs and social requests.
- Personalized learning involves combining formal and non-formal education. Informal education is based on certain principles, the most important of which are: learning by doing, collaboration and ability and willingness to self-education and self-improvement. The main method of non-formal education is research. At the same time, students must have similar experience in formal education for the active perception of the model of "flipped" learning. That is, they should be prepared for the implementation of the model.
- Today, in the Internet it is possible to find content that "provides" the study of many disciplines. Moreover, the forms of content representation are often more modern and diverse than the presentation by the teacher in the educational audience. Thus, having an Internet connection is the only obstacle to obtaining relevant data in accordance with the student's

learning style and with the ability to critically evaluate and analyze content from various sources.

- Lectures in any form: face-to-face, videos, podcasts, should support learning, but do not form the basis (to be the core) of studying a particular discipline. So, the effectiveness of the lecture depends on the context of the presentation, for example, after the students conducted some experiments or research (empirical, with the help of laboratory equipment or simulation means) and developed their own questions, hypotheses, ideas.
- During their studies, students should build practical confirmation of the learning results and reflection system of their own activities, as well as be able to obtain expert assessment or counseling, networking, and communication.
- The "flipping" of the learning can be done only by a teacher-facilitator, manager, expert.

The flipped learning model can be used for holding almost any lesson, but involves a thorough training of teachers and students (Bergmann, Sams, Aaron, 2014).

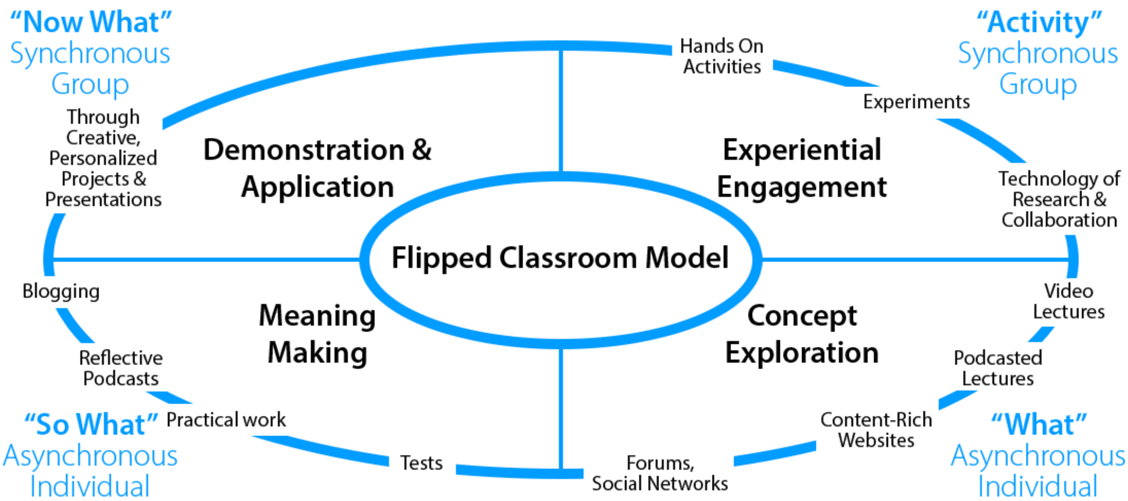

Figure 2: Flipped learning model (Source: Own work based on https://usergeneratededucation.wordpress.com/2011/06/13/the-flipped-classroom-model-a-full-picture/)

3. Preparation of the materials according to the students experience

Problem of Research. The virtual learning environment of modern educational institution not always take accounts a learning needs of its students, content and technology that they use in creating and maintaining their own personal educational environments (Morze, Spivak, Smyrnova-Trybulska, 2015).

Research question: Or the quality of the virtual learning environment of modern educational institution must be based on learning needs of its students, content and technology?

Hypotheses: The quality of the virtual learning environment of modern educational institution must be based on learning needs of its students, content and technology that they use in creating and maintaining their own personal educational environments, and depends on the level of ICT competence. Independent variables own personal educational environments of students dependent variables the level of ICT competence.

Study participants and procedure. According to the scenario of the pedagogical experiment, at the first phase the students from Ukraint and Poland were presented with more than 40 positions of various contemporary Web services and applications, on which individual electronic educational platforms of content management and electronic communication, cooperation and solution of educational and scientific problems that enable students to set learning goals and manage their personal process of academic progress monitoring were based and, on the basis of a portfolio to form their personal e-learning space, conduct and publish educational and scientific project activities, etc. From this list respondents had to choose forms of learning, frequency of use and type of activity among which they distributed the proposed web services and applications.

Results of Research. Among the results of this article (reference to the article (Morze, Spivak, Smyrnova-Trybulska, 2015), which is the subject of this article, it is identify the tools and technologies that students prefer during their preparation for classes and presenting results of their own activities (Table 1)

Table 1: Percentage distribution of answers of students from Poland and Ukraine in the group of questions reflecting students' educational strategies.

Question	Poland	Ukraine
If you have access to the Internet, with what aim do you use it most frequently?		
To search for course materials, to advance your own knowledge	79,5%	87,2%
To participate in the e-learning course(s)	41,9%	27,4%
To contact friends (e-mail, social network, messenger)	72,4%	90,3%
For file sharing (P2P)	15,2%	42,1%
To develop your interests, hobbies	42,9%	72,2%
Looking for interesting materials on the Internet, do you use most frequently:		
Search systems, for example, Google	84,8%	85,1%
Video, for example, YouTube	53,3%	81,5%
Electronic catalogues (bibliographical references and data bases)	21,9%	37,3%
Social networks	21,9%	31,3%
Reliable and well-tested portals	33,3%	37,2%
Blogs	6,8%	7,1%
What methods of submitting final work for checking to the instructor do you consider the most effective?		
By means of the distance learning platform, for example the Moodle system or similar ones (Forum, Tasks, etc.)	31,4%	18%
Social networks	83,8%	19%
Traditional paper forms (press, photo-copying)	27,6%	35%
Orally during the classes	5,7%	47%

Source: own research

Thus, for the implementation of the flipped learning model, a list of tools that the teacher should use to prepare materials and support the "flipping" was compiled.

Table 2: Implementation of the flipped learning model by implementing learning teamwork and creating of students PLE

Tasks	PLE resources examples
Experiential engagement	
Organization of group work	Google Apps, Microsoft Office 365
Communication of participants	Facebook, G+
Selection of resources and tools	MS Office, Prezi, Google Apps, ThinkLink …
Creating resources and their integration	Google Sites, Blog, YouTube, Mind Mapping
Concept exploration	
Theoretical materials and embodiments	Moodle, Google Classroom, Wiki
Learning videos	YouTube
Instructions for the organization of work, use of services and present the results of work	Wiki, Google Docx, Padlet
Forms of assessment	http://www.intel.com/content/www/us/en/education/k12/assessing-projects/strategies.html
Meaning marking	
Tests	Kahoot, Survey, Quizizz, Typeform
Questionnaires and check-lists	Google Apps
Project blog	Google Sites, Blog
Demonstration and application	
Project presentation	Prezi, Slideshark, Powtoon, Keynote
Video Essays	YouTube
Electronic assessment	Google Apps, Forums

CONCLUSIONS

On the basis of these results we can draw the following conclusions:

1. Development of XXI century skills and information literacy of students in the implementation of the flipped learning model is provided in the implementation of the following pedagogical conditions:

- involvement of students in independent cognitive and practical activities;
- creation of the students objective at mastering complex skills of self-education, experimental and scientific creativity
- the use of modern information technology and services
- monitoring the needs of the students of a specific group and flexible responsiveness by the teachers (courses design);
- freedom of choice, that is, the implementation of the student's subject position.

2. Pedagogical design is the basis for designing courses with the usage of flipped learning technologies:

- Script development
- Selection of evaluation tools
- Implementation of quality control

3. Further research perspectives are an analysis of the potential of using the model of flipped learning in the system of qualification upgrading teachers training.

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REFERENCES

El-Mowafy Ahmed, Kuhn Michael and Snow Tony (2013). Blended learning in higher education: Current and future challenges in surveying education. In Special issue: Teaching and learning in higher education: Western Australia's TL Forum. Issues In Educational Research, 23(2), 132-150. Available from: http://www.iier.org.au/iier23/el-mowafy.html (June 22 2017).

Bergmann, Jon Sams, Aaron (2014). *Flipped learning: Maximizing Face Time*. In: T+D. Feb 2014, Vol. 68 Issue 2, p28-31. 4p., ISSN: 1535-7740. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=f5h&AN=94004879&site=ehost-live. (June 22, 2017)

Marshall H. *Three reasons to flip your classroom* // Bilingual Basics. August, 2013. Available from: http://newsmanager.commpartners.com/tesolbeis/issues/2013-08-28/6.html (June 23 2017).

Morze N., Spivak S., Smyrnova-Trybulska E. (2015). *Designing a Modern Cloud-Oriented Virtual Personalized Educational Environment*, New Educational Review 2015, Vol. 40. No. 2, pp.140-154. ISSN 1732-6729

New ISO standard aims to improve quality of learning services and facilitate comparison on worldwide basis (2010). Available from: http://www.iso.org/iso/home/news_index/news_archive/news.htm?refid=Ref1384 (June 23 2017)

Miller R., Shapiro H., Hilding-Hamann K.E. (2008). *School's Over: Learning Spaces in Europe in 2020: An Imagining Exercise on the Future of Learning* // Office for Official Publications of the European Communities. – 2008. – 94 p. Available from: http://ftp.jrc.es/EURdoc/JRC47412.pdf (June 23 2017)

PREPARATION AND INSTRUCTION IN MOOC

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Abstract

MOOC (Massive Online Open Courses) are a modern solution for supporting distance learning which was made possible by the availability of the Internet and the development of multimedia. Within the scope of the IRNet project (www.irnet.us.edu.pl), which is being conducted by the University of Ostrava and a number of universities from other countries, the MOOC course "ICT tools for e-learning" was created. Each of the participating parties was responsible for creating one module aimed at a current topic in the field of ICT in education. Therefore, the course consists of modules which represent independent units. The complex course is available to students from all universities.

The paper analyzes possible approaches to creating an MOOC which were used by the project partners in creating the course. Moreover, the paper focuses on the structure of the individual modules and the use of multimedia elements, especially video recordings (how to present the curriculum using different types of video formats). Furthermore, the paper also analyzes tests and test questions, which are the self-evaluation part of an MOOC.

Keywords

MOOC, distance learning, video tutorial, evaluation.

INTRODUCTION

The project "IRNet – International Research Network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences", in which teams from both EU and non-EU universities participate, focuses on designing a program aimed at ICT tools, distance learning, MOOC and international and intercultural competencies. Creating the MOOC "ICT tools for learning" is one of the project outcomes. Each team is responsible for creating one educational module of the aforementioned course, which will be available to students from all universities. Within the scope of the IRNet project, the University of Ostrava research team created the module "Tools for Adaptive Learning. Learning Styles" (Malach et al., 2016).

Intended for an unlimited number of participants, MOOC are educational courses accessible via the Internet (Kaplan et al., 2016). The fact that these courses are accessible via the Internet allows for the use of multimedia elements, video tutorials in particular. Discussion on message boards and interaction between students and teachers are the main advantages of MOOC.

A number of authors focus on creating the methodology for MOOC-based instruction, including the creation of courses. Masters (2011) summarizes the basic principles of MOOC-based instruction while Jenner describes the advantages of MOOC. Colley (2015) introduces recommendations for creating MOOC at udemy.com, which is one of the world's biggest learning platforms offering MOOC-based instruction.

COURSE STRUCTURE

The aim of the MOOC "ICT tools for e-learning", which was created within the scope of the IRNet project, was sharing of experience between the partners and developing MOOC-based distance learning. The course introduction was aimed at comparing MOOC with other forms of ICT-based distance learning (Morze et al., 2016) and developing a methodology for creating distance learning (the instructional system design using the ADDIE model (Kapounová & Pavlíček, 2002)).

The course consisted of a number of independent modules created by the project partners. Those modules were in fact independent MOOC. Each of the modules is aimed at one ICT tool which can be used in distance learning and e-learning:

- ICT tools for presenting the content of the curriculum, focusing on creating digital video recordings
- ICT tools for adaptive instruction (Czeczotková & Prextová, 2014) aimed at the student's learning styles
- Tools for creating mind maps and graphic presentation of information
- Specific e-learning tools – gamification and rewards in education
- ICT tools for collaborative learning and cooperation
- Tools for evaluation and assessment
- Digital storytelling
- Tools for developing multicultural competencies, for social work and for supporting students with specific educational needs

The individual modules had a well-defined structure. At the beginning, the course objectives and key terms were introduced using a mind map. This was followed by the instructional part which included materials in the form of video recordings, textbooks and presentations summarizing the basic terminology. Each instructional part was concluded with test questions aimed at self-evaluation. The final part of the module included a summary and a final test aimed at assessing the student's performance within the module.

During the course of instruction, the students were presented with questionnaires aimed at determining their opinion on the particular topic and discussion forums were added.

Instructional video recordings

Instructional video recordings have become a popular technology in education. The possibilities for the use of instructional video recordings go hand in hand with the development of technology which enables the creation of video recordings (Oujezdský et al., 2014), new ways of publishing a video on the Internet, massive use of mobile devices which enable video recording and editing (Klubal & Kostolányová, 2016), etc.

MOOC are based on video lessons and the use of all the other distance learning tools and possibilities of systems for organization and management of instruction. There are a variety of methods of processing instructional videos. We will focus on those used in the "ICT tools for e-learning" course.

The basic instructional video is a recording of a lecture. The video captures the lecturer in a dialogue with the listeners. For better clarity, the video contains images of a blackboard and/or presentation slides. The video recordings of lectures can be viewed at www.ted.com.

The "lecture videos" can be recorded during the lectures. However, nowadays they are often recorded without the listeners – the lecturer speaks to the listeners behind the camera. Oftentimes, the shot shows the lecturer from head to toe; a different angle is used every time the topic of the lecture changes. This method of video recording has become popular among young people – it is used by YouTubers.

In addition to the "lecture videos", presentation videos and blackboard video tutorials are also used in instruction. Such videos are often used in mathematics instruction, e.g. Khan Academy (www.khanacademy.org/). The teacher can use presentation software (e.g. MS PowerPoint) to create such videos. Apart from regular presentation techniques, presentation software enables the creation and use of animations and addition of audio commentary. The software then generates a video recording of the presentation with animations and audio tracks. This was the most used form of video recording in the course.

An instructional video can combine both options – the face of the lecturer is shown on the background of the presentation (two ways – see Figure 1). However, it is important that the face of the lecturer does not block the text of the presentation (the left picture).

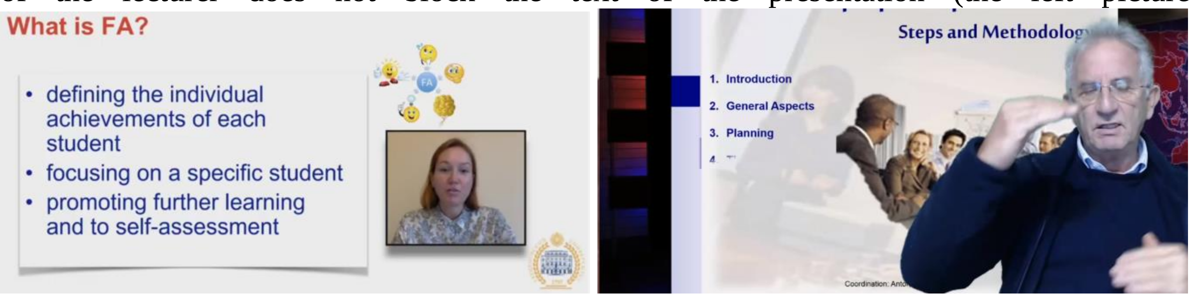

Figure 4: Instructional video – presentation and live recording of the lecturer

Tests and test questions

A test is a useful tool which informs both the teacher and the student about their knowledge, skills and progress. According to Wiersma, W. and Jurs, S. G. (2006), "a test provides information about one's knowledge and skills in a particular area". Rosa (2007) describes a test as "a set of tasks, each of which is either a question the respondent is supposed to answer, a problem which they are supposed to solve or instruction for conducting a particular activity".

Just as there are many definitions and approaches to testing, there are many test categories and many types of test tasks used in them. We will focus on those used most often in the individual modules of the "ICT tools for e-learning" course. The following table shows the used *test categories*:

Table 4: Test categories in MOOC

Criterion	Division
Degree of preparation and nature of the knowledge test	Non-standardized (created by the author)
Nature of tested activities	Cognitive (determining knowledge and intellectual skills)
When it is taken (at what stage of the education process)	Input (pretest)
	Control (at the end of individual chapters)
	Output (final test)
Degree of objectivity of evaluation (grading)	Objectively scored (graded automatically)
	Subjectively scored (graded by the author)
Measured performance characteristics	Student's level
Number of tested topics	Polythematic (testing different topics from different modules)

The following are the most often used *test tasks*:

Table 5: Types of test tasks in MOOC

Closed-ended test tasks	Multiple choice questions with one correct answer
	Multiple choice questions with one or more than one correct answer
	Drop down menu questions
	Drag-and-drop matching questions
	Drag-and-drop onto image questions
	Dichotomous (True/False)
Open-ended test tasks	Long answer questions
	Short answer questions

DISCUSION AND CONCLUSION

The creation of an MOOC is extremely challenging as it requires more than dividing the curriculum into individual units, which include examples and activities which will be presented in instruction. The creation of instructional videos requires technical skills and the following personal characteristics – sophisticated speech, presentation, mimics, but also passion for the presented topic and creativity. Since the majority of MOOC are taught in English, the teacher should know English.

Similarly, the MOOC instruction differs quite significantly from regular instruction. In MOOC, the student is expected to be motivated to study, to be interested in the topic. As a result, the student is engaged in discussions more often, expresses their opinions on discussion boards; they also ask questions and communicate. The different role of the student goes hand in hand with the different role of the tutor in an MOOC.

The MOOC "ICT tools for e-learning" is now being pilot tested at universities (groups of students). The course is a unique work created by the participating universities. A number of university teachers use MOOC to share their knowledge and experience with the public in an unusual way, which is different from university instruction. It is possible that the approach of MOOC shows the way for ICT-based instruction, including the role of the teacher in the digital age (Neumajer, 2014).

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REFERENCES

Colley, J. (2015) *Udemy: 25 Tips to Make Great Online Courses on Udemy with marketing and video production.* Available from: https://www.youtube.com/watch?v=6wV_t9y-0FU.

Czeczotková, B. & Prextová, T. (2014) Creation of study materials for adaptive learning. *Jounal of Technology and Information Education.* 6(1), 57-70.

Jenner, M. (2014) *What's the benefit of MOOCs?.* London: UCL. Available from: http://blogs.ucl.ac.uk/digital-education/2014/03/25/whats-the-benefit-of-moocs/.

Kaplan, A, M. & Haenlein, M. (2016) Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizons*, 59 (4), 441–450.

Kapounová, J. & Pavlíček, J. (2002) *Computers in teaching and learning*. Ostrava: Ostrava University.

Klubal, L. & Kostolányová, K. (2016) Forms of the materials shared between a teacher and a pupil. *12th international conference on mobile learning* (pp. 157-160). Algarve: IADIS Press.

Malach, J., Kostolányová, K., Chmura, M., Nagyová, I. & Prextová, T. (2016) Objectives and Content of E-module "Tools for Adaptive Learning. Learning Styles" within the MOOC Course "ICT Tools for E-learning. *International Journal of Research in E-learning*, 2 (1), 28–40.

Masters. K. (2011) A Brief Guide To Understanding MOOCs. *The Internet Journal of Medical Education,* 1(2).

Morze, N., Makhachashwili, R. & Smyrnova-Trybulska, E. (2016) Research in education: Survey study. *Information and Communication Technology in Education* (pp. 114-123). Ostrava: Ostrava University.

Neumajer, O. (2014) Kalaš, I. a kol. School Changes in Digital Age. *Pedagogika*, 2014(1), pp. 130-133 (review).

Oujezdský, A., Slíva, A. & Brázda, R. (2014) Creating and Using Educational Video Tutorials in Classes. *INTED2014.* (pp. 7168-7173). Spain: IATED Academy.

Rosa, V. (2007) Methodology for Creation of Didactic Tests, *National Pedagogical Institution*, Bratislava.

Wiersma, W., & Jurs, S.G. (2006) Educational Measurement and Testing, Allyn and Bacon, Inc, Boston.

FORMS OF WRITING ALGORITHMS IN SCHOOL TASKS

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Abstract

Developing informatics thinking, focusing on an algorithmic approach to problem solving is an integral part of informatics instruction at both elementary schools and high schools. The complexity and diversity of informatics instruction can be ensured not only by diverse tasks, but also diverse approaches to the task and diverse results. The diversity of tasks depends on the context into which a task is placed. The student needs not only to understand the context, but also be able to create a problem solving process in the required form, i.e. write an algorithm.

Intended for elementary and high school students, the informatics competition "Beaver of Informatics" is held in a number of countries all around the world. During the course of the competition, students solve various informatics problems, many of which are aimed at informatics thinking. Following the analysis of the competition tasks, task categories were defined with regard to the way of writing the solution, i.e. the way of writing the algorithm. The paper introduces the results of the analysis of the "Beaver of Informatics" tasks intended for elementary school students, which were aimed at forms of writing simple algorithms.

Keywords

Beaver of Informatics, algorithms, algorithmic thinking, informatics, task, form of writing algorithms.

INTRODUCTION

An algorithm is a set of instructions for solving a task (Šarmanová, 2014). Various methods are used to present algorithms. An algorithm can be written in words, e.g. a recipe in a cookbook, operating manual, etc. In informatics, special languages (pseudo languages) are used for writing algorithms. Moreover, algorithms can also be graphically represented by a flowchart (Kostolányová, 2002). If an algorithm is to be machine-implemented (using a computer), it needs to be translated into a programming language.

Algorithmization and the development of algorithmic thinking (Hromkovič et al., 2016) incorporates the development of the ability to apply and modify existing algorithms, propose and create precise instructions and verify their correctness and effectiveness (Wing, 2006). Suitable educational programming environments can be used for instructing and practicing algorithmization. There are two types of program environments: 'open' (Scratch, Baltík, etc.) which do not contain educational content; the nature of work in those environments is determined by the teacher, and 'closed' (Code Class, EasyLogo, Blockly) which contain series of related programming tasks (Vaníček, 2016); instruction of algorithmization in those environments is practical – students solve short problems and/or work on projects. As a result, the student gains experience which they can use when solving a more complicated problem.

The majority of tasks in the Beaver of Informatics competition are situational tasks, i.e. tasks that represent a situation in which the student needs to be able to orientate themselves and also understand the terminology. The majority of the competition tasks are aimed at algorithmization. The diversity and difficulty of individual tasks depends on diversity of the situations which are described, more or less, formally. The paper is aimed at the outputs of algorithmic tasks and the methods for writing algorithms and their interpretation.

FORMS OF WRITING ALGORITHMS

The competition tasks use the common method for writing algorithms. There are tasks which contain algorithms written in the Scratch programming language – especially tasks intended for high school students, but also tasks containing pseudo codes. Algorithms graphically represented by flowcharts and/or graphs are very common. In those tasks, the situation is usually presented graphically, making the orientation extremely difficult. Therefore, more points are awarded for those tasks. However, other ways of writing algorithms can be found in the tasks.

Verbal description

Verbally written algorithms are the most natural algorithms. Even though verbal descriptions and instructions are common, they are often inaccurate because of incomplete/confusing formulation. For example, the instruction "Pour hot water on a tea bag" can lead to burning if one does not put the tea bag in the cup (as the task assignor expects them to).

In an effort to avoid such inaccuracies, there is a tendency to formalize the verbal description of the algorithm, i.e. to separate commands necessary for solving the problem and assign fixed phrases to them. The following example only contains three commands (pour out, pour and fill with water) in different orders, depending on the glass number.

2013 Cadet Category task:

An absentminded waiter poured 1 strawberry juice, 1 lemon juice, 1 orange juice and 1 water (H_2O) into 4 glasses. Since he was not careful enough, he did not pour the drinks in glasses with correct pictures.

Current contents of glasses:

Glass 1 contains orange juice instead of strawberry juice, Glass 2 contains strawberry juice instead of lemon juice, Glass 3 contains lemon juice instead of orange juice and Glass 4 – correctly – contains water. The waiter does not have any more glasses.

What should the waiter do in order to replace the drinks so each glass would contain the correct drink?

a) Pour 4 into the sink, pour 1 into 4, pour 2 into 1, pour 3 into 2, pour 4 into 3, fill 4 with water.

b) Pour 4 into the sink, pour 2 into 1, pour 3 into 2, pour 1 into 3, fill 4 with water.

c) Pour 2 into 1, pour 3 into 2, pour 1 into 3.

d) Pour 2 into 1, pour 3 into 2, pour 2 into 1.

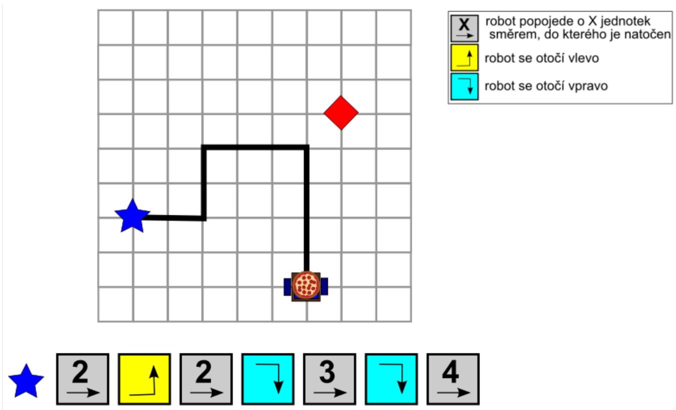
Writing using icons

Tasks containing movement, e.g. describe the route of movement from Point A to Point B or enter instructions of the movement of a figure, are common situational tasks for beginners in the field of algorithmization. A robot is often the main character in these tasks. The robot follows the commands – go forward, turn left, turn right, etc. The idea of a moving robot controlled by a set of commands led to the creation of the educational programming environment Karel the Robot (Pattis, 1981), or the Logo programming language, created by Papert (1980).

Tasks containing movement with a limited set of commands allow for the algorithm – commands that control the robot – to be written using symbols and/or icons. Aimed at finding the error in the algorithm, the following task uses icons.

2015 Benjamin Category task:

The main attraction in a restaurant is a robotic waiter which delivers pizza. The cook wants the robot to deliver pizza from the bar (the blue star) to the red table (the square). Unfortunately, since the cook wrote an erroneous program (below the figure), the robot ended up at the wrong table. Two of the commands are redundant. Select those two commands by clicking on them and delete them to make the program correct.



Code algorithm

In connection with verbally written algorithms and their formalization, it is logical to introduce signs and abbreviations for individual commands. Intended for older students, the following task contains not only command coding, but also repetition of a set of commands. From the algorithmization perspective, the task is aimed at verifying the correctness of the algorithm (the student chooses the correct option).

2016 Cadet Category task:

Thomas wrote a program for drawing flags. In his program, commands for drawing squares and triangles can be used to draw a line with flags. The program contains the following commands:

- bS – large square
- sS – small square
- bT – large triangle
- sT – small triangle

Apart from the commands, the following command for repetition can also be used:

- C [Tvar], where C is the number of repetitions and Tvar is the order of commands.

This allows the program to write all the flags that follow one another at once. For example, the program sS 2[bT sT] bS will draw the following line with flags:

Which program will draw this line with flags?

a) bS 3 [sT sS bT] sT bS
b) bS 3 [sT sS bT] bS
c) bS 2 [sT sS bT] sT bS
d) sS 3 [sT sS bT] sT sS

CONCLUSION

Education in the field of algorithmization enables teaching of basic informatics terms and concepts and development of algorithmic thinking as an integral part of education in the modern age. However, it is necessary to overcome the difficulty of algorithmization in order to be able to exploit the potential of algorithmic thinking which is important for understanding the world of digital technology.

In the paper, we presented examples of different ways of writing algorithms in tasks intended for elementary and high school students. This “algorithm language” shows how algorithmization can be made more understandable for students. In order to overcome the transmissive approach to instruction (Nagyová, 2016) and point out the possibilities for solving everyday problems using digital technology tools, the tasks can be further developed and modified by changing the situations and commands.

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REFERENCES

Beaver of Informatics, the official website of the informatics competition for elementary and high school students. České Budějovice: JU. Available at: https://www.ibobr.cz/

Hromkovič, J., Kohn, T., Komm, D. & Serafini, G. (2016) Examples of Algorithmic Thinking in Programming Education. *Olympiads in informatics,* 10(1), 111 – 124. Available at: http://www.ioinformatics.org/oi_index.shtml

Kostolányová, K. (2002) *Algorithmization and problem-solving.* Ostrava: OU.

Nagyová, I. (2016) Constructivism in teaching of basic computer skills. *ICTE 2016.* Ostrava: OU. 126 – 132.

Papert, S. A. (1980) Mindstorms. Brighton: The Harvester Press.

Pattis, R. E. (1981) *Karel The Robot: A Gentle Introduction to the Art of Programming.* NY: John Wiley & Sons.

Šarmanová, J. (2014) *Algorithmization and problem-solving.* Ostrava: OU.

Vaníček, J. (2016) Algorithmization instruction is part of informatics. *Computer at school 2016 – national conference of elementary and high school teachers.* Nové Město na Moravě. Available at: http://www.pocitacveskole.cz/system/files/soubory/sbornik/2016/vanicek1.pdf

Wing, J. (2006) Computational thinking. *Communications of the ACM*, 49 (3), 33 – 35 Available from: https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf

ICT VE VÝUCE HUDEBNÍ VÝCHOVY NA ZÁKLADNÍ ŠKOLE

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Abstract

Příspěvek je zaměřen na hledání a zkoumání možnosti využití ICT a mobilních technologií jako prostředku podpory žákovské kreativity a kooperace i jako prvku motivačního v edukačním procesu hudební výchovy. Sleduje účinnost využití ICT prvku při edukaci z pohledu učitele i žáka.

Keywords

ICT gramotnost, mobilní technologie, dotyková zařízení, modernizace výuky, hudební výchova, kreativita, kompetence, motivace, kooperace a aktivizace žáků.

ÚVOD

Současným trendem školství na všech jeho úrovních je hledání a zavádění nových učebních strategií s cílem zlepšit kvalitu vzdělávání. Digitalizace učebních materiálů a smysluplná implementace moderních prostředků informačních a komunikačních technologií (ICT) do přímého procesu edukace je jednou z možných cest. Většina výzkumných dokumentů zaměřujících se na podobnou tématiku zkoumá využití ICT z hlediska přípravy na výukovou jednotku. V hudební výchově jde především o zkoumání práce učitele při použití notačních programů a softwarů v přípravě výukových materiálů. Náš výzkum je zaměřen na modernizaci HV v přímé výuce. Objektem zkoumání jsou ICT užité ve většině jejich kategorií.

EDUKACE HV S VYUŽITÍM ICT

Inovativní tendence výuky hudební výchovy

Učitelé z praxe chtějí modernizovat výuku svých předmětů. Důkazem je vznik portálů s výukovými materiály jako např. www.rvp.cz, www.ceskaskola, www.edu.cz, www.dumy.cz, www.veskole.cz. Tyto portály učitelé využívají pro vzájemné sdílení zkušeností i materiálů z výuky. Případně umožňují materiály sdílet i svým žákům. K nalezení je mnoho inspirativních materiálů. Nutno také konstatovat, že mnoho z těchto DUMů (digitálních učebních materiálů) sice prokazují hudební znalosti tvůrců a jejich technické dovednosti při práci s ICT, ale mnohé z nich také z didaktického hlediska nejsou dobře zpracované. Zejména PowerPointové prezentace, které jsou spíše souhrnem informací, většinou postrádají hudebně - výchovné prvky či prvky interaktivity. (Otázky k zamyšlení, otázky k diskusi, drobné úkoly, pracovní listy). Míra atraktivity edukačních prostředků pak může převýšit míru splnění výukových cílů. V inovativním procesu své místo nalézají i interaktivní učebnice např. učebnice nakladatelství Fraus či Nová škola či euroDIDACT. Významnou roli pro sdílení zkušeností z výuky má i využití webových stránek veřejných či soukromých, sociálních sítí a dalších virtuálních prostředí. Pro moderní výuku hudební výchovy nelze nepřipomenout i inspirativní metodický blog s videonávody a odkazy paní Lenky Pobudové http://jaknahudebku.blogspot.cz/.

Tolik popis ICT užitých při vzájemné spolupráci mezi učiteli. Předmětem našeho zájmu je ovšem využití ICT především během běžné školní praxe, v interakci učitel – žák či žáci mezi sebou.

Jestliže mají ICT posílit edukační proces, neměly by být používány pouze jako projekční nástroj. Má-li být užití informačních a komunikačních technologií v přímém procesu výuky smysluplné a účelné, dle Průchy (1997, str. 307) mělo by splňovat tyto charakteristiky:

a) užívání interaktivních prostředků pro předávání informací v obousměrné komunikaci

b) kombinované informace, obsahující obraz, zvuk, klasickou písemnou informaci

c) víceúrovňová informace, obsahující možnost postupovat v textu různými směry (hypertext)

Jan Průcha (1997, str. 324) také používá pojem komunikační ostýchavost. Každé dítě touží po úspěchu, ale strach z nezdaru či posměchu spolužáků právě při hudebních činnostech mnohé děti při jejich výkonu svazuje či omezuje. ICT může přinést možnost změnit edukační prostředí a vytvořit bezpečné podmínky pro úspěšné splnění úkolu i pro tyto žáky (viz níže – záznam kreativní hudebně- pohybové činnosti).

Další autor -Yves Bertrand (1998, str. 103) charakterizuje infomační technologie jako zajímavý nástroj vzdělávání, který usnadňuje mimo jiné interaktivní integraci rozmanitých medií a snazší přístup k poznatkům v přirozeném jazyce i v grafickém vyjádření a kooperativní užívání poznatků.

Z těchto charakteristik také vychází podoba zkoumaných nových výukových materiálů, které mají za úkol podpořit nejen hudebně- kognitivní činnosti žáků, ale také žákovskou kooperaci a participaci v edukačním procesu HV.

Průběh výzkumu

Cíl práce bude dosažen pomocí kvantitativního výzkumu s prvky výzkumu kvalitativního.

1) zjištění míry a způsobu využití ICT v HV – dotazníkové šetření s uzavřenými otázkami s možností zápisu doplňujících informací
2) příprava a ověření digitálních učebních materiálů a pracovních listů s interaktivními činnostmi
3) pilotní výuka s pozorováním
4) kvalitativní výzkum – dotazníkové šetření (míra spokojenosti využití ICT pohledem učitele i žáka)
5) kvantitativní výzkum – experimentální metoda (porovnání edukace s využitím ICT a bez ní)
6) statistické zpracování dat

Průzkum míry a způsobu využití ICT v HV

Sběr dat pro první část výzkumu proběhl dotazníkovým šetřením v minulém roce. Dotazník byl rozeslán elektronicky na základní školy a gymnázia v České republice. Osloveno bylo 721 respondentů. Návratnost byla 131, toto číslo odpovídá 18,2 % celkově dotazovaných. Cílem výzkumu bylo zjistit jaká je vybavenost učitelů hudební výchovy ICT prvky a pomůckami pro svou práci. Dále jejich využitím v hodinách v souvislosti s hudebními i výukovými činnostmi při přímé výuce Hv a v přípravě na výukovou jednotku z pozice učitele i žáka. Využitelnost ICT též vyhodnotit ve vztahu věku, pohlaví a aprobovanosti učitelů. Z analýzy výzkumu plyne, že učitelé všech typů škol, věkových kategorií i všech možností aprobací se snaží prvky ICT využívat. Zastoupení ICT ve všech kategoriích hudebních činností je potěšitelné. Nejčastější užití zaznamenaly předpokládané poslechové činnosti, v hodnocení následují pohybové a intonační činnosti. ICT dle odpovědí respondentů podporují i kreativní činnosti žáků. V malé míře se objevilo využití prvků ICT i pro přímou komunikaci učitele se žákem.

Dříve mnoho přístrojů v učebně mohlo znamenat jistou finanční zátěž. Většinu přístrojů dnes nahrazují dokonalé funkce počítačů, notebooků a mobilních zařízení. Univerzálnost jejich použití je zřejmá. V průzkumném šetření 67,9 % respondentů odpovědělo, že tablet nemá k dispozici. Dle našeho názoru, ale využití právě tohoto zařízení či tzv. „chytrého telefonu" má pro hudební výchovu velký potenciál a dává možnost jeho maximálního využití. Jejich multifunkčnost (multimediální zdroj informací, alternativa hudebního nástroje, komunikační nástroj, záznam činností) dává možnost hledat inovativní či alternativní postupy při využití těchto zařízení při výuce.

Pilotní výuka

Pilotní výuky se účastnili žáci druhého stupně vzdělávání na FZŠ Hálkova Olomouc. Před zahájením pilotáže proběhlo ověření technických možností žáků a školy a následné zajištění dalšího potřebného technického zázemí výzkumu. Příprava pokračovala tvorbou materiálů určených k výzkumu. Zaměřili jsme se na využití dotykových zařízení při hudebních činnostech během výuky. Užití moderních technologií, obzvlášť vlastních žákovských zařízení, pohledem vyučující činilo učební jednotky žákům atraktivnější. Tato skutečnost se projevila zvýšenou participací „nehudebních žáků" na výuce a také jejich zvýšenou aktivitou. Jevila se též podpora kooperace žáků při edukační činnosti.

Hudební aktivity s využitím ICT

Při hodinách Hv byly užity prvky ICT různým způsobem:

a) alternativní způsobu testování či rychlá evaluace výuky s využitím dotykových zařízení (Kahoot, Moodle)

b) záznam zpracování kreativního skupinového úkolu – videodokumentace a následný rozbor

c) samostatná či skupinová práce při poslechových aktivitách a při instrumentálních činnostech. (užití dotykových zařízení, počítačů a sluchátek, intonační či rytmický výcvik, vizualizace hudby – grafické zpracování hudby, pohyblivá partitura)

d) užití QR kódů při tvorbě inetraktivních výukových materiálů

<u>Videozáznam kreativní hudebně – pohybové aktivity</u> – individuální nebo skupinová tvorba, při které se děti snaží komunikovat pomocí vlastního hudebního projevu. Vede k lepšímu porozumění skladatelských sdělení a pochopení pojmu hudebně výrazové prostředky. Změna

edukačního prostředí (děti dostanou prostor zdárně a klidně splnit zadaný úkol mimo školu s pořízením videozáznamu výkonu, což jistě ocení především ostýchavé děti, či žáci se specifickými potřebami učení, zejména žáci s autistickými rysy) dává možnost individuálního přístupu k žákům a jeví se jako vhodná alternativa pro splnění zadaného úkolu. Aktivita žáků při samotném plnění úkolů byla zřejmější. Což potvrdily i doplňující informace žáků z pilotního výzkumu:

žák 1 : „ …nemusel jsem se bát, že se mi budou spolužáci smát.."

žák 2 : „ ..mnohem méně jsem se styděl…"

žák 3 : „ mohli jsme vybrat ten nejlepší"

Sociální klíma třídy má jednoznačně vliv na průběh hudebních činností i na volbu postupů plnění zadaných úkolů. Citlivě vedená aktivta může být nápomocná při budování pozitivních sociálních vztahů mezi žáky. V dotaznících žáci udělovali pořadí způsobům řešení úkolu podle své preference od nejlepší varianty po nejhorší. Otázka byla mířena na samostatnou hudebně-pohybovou aktivitu a výběr varianty měl zajistit nejlepší výkon žáka. Výsledky šetření ukazuje tab č. 1. Ve všech skupinách je jednoznačná preference prezentace úkolu pomocí videozáznamu pouze před učitelem, následovaná osobní prezentací pouze před učitelem. Další pořadí je ovlivněno klimatem třídy. Ve třídě s bezpečnějším klimatem je další možnou volbou přímá prezentace před kolektivem, ve třídě s horším třídním klimatem žáci raději volí opět videozáznam.

<u>Evaluace vědomostí</u> prostřednictvím hlasovacího či dotykového zařízení. V přípravné fázi výzkumu žáci jevili zvýšený zájem o tuto činnost. Otázkou je, zda kvůli alternativnímu způsobu provedení testování, či kvůli touze být úspěšný při veřejné prezentaci výsledků testu. Předpokladem je, že po užití této techniky zůstanou vědomosti (dovednosti) žáků trvalejší. Hypotéza bude ověřena na dalších výzkumných vzorcích.

<u>Instrumentální dovednosti</u> – pohyblivá partitura a hra na boomwkackery či jiné nástroje. (Možnost využití mobilních zařízení.) V pilotní fázi z dětí byla znát zřejmá radost z instrumentální hry bez znalosti notopisu a rytmu. Nutno ověřit spokojenost a srovnání s užitím běžné partitury a nástrojů, také zjistit zda tato aktivita působí jako motivační prvek k doplnění znalostí.

<u>Využití QR kódů</u> – pomocník v přípravě interaktivních materiálů. Vznikly hudební hádanky a pracovní listy pro aktivní poslechové činnosti. V přípravné fázi zřejmý zájem žáků o činnost, plnění dobrovolných úkolů- příprava vlastních hudebních hádanek. Podpořeno kooperativní chování žáků.

Z pilotních žákovských dotazníků vzešla i žádost o další využití školního prostředí Moodlu pro vyvěšení dalších materiálů- noty, doprovody, prezentace, texty písní.

Výzkum efektivity a spokojenosti s využití ICT v hodinách

Metodou samotného sběru dat bude použit dotazník, který sleduje:

a) Spokojenost s výukou s využitím IT pohledem žáka

Akcent bude kladen především na:

- Náročnost zvládnutí IT při výuce
- Časová náročnost domácí přípravy
- „Zábavnost“ výuky
- Rychlost zpětné vazby od pedagoga
- Využití připravených materiálů při samostudiu
- Zjednodušení formy prověřování vědomostí a dovedností
- Soukromí při prověřování dovedností a znalostí (eliminace trémy při přezkušování před kolektivem třídy)
- Schopnost účasti na přípravě cvičných testů

b) Spokojenost s výukou s využitím IT pohledem učitele

Výzkum v této rovině bude realizován analogicky s rovinou předchozí, s akcentem na:

- Náročnost přípravy na danou výuku
- Možnosti testování výstupů z učení
- Aktivita a participace žáků
- Časová úspora při vyhodnocování testů
- Časová dotace IT v průběhu vyučovací jednotky
- Možnost diferenciace žáků
- Individuální přístup k žákovi

ZÁVĚR

Práce se zmíněnými technologiemi je žákům a studentům blízká a zvýšená míra jejich použití při plnění studijních povinností by mohla vést k aktivizaci studentské či žákovské kooperace, ke zvýšené participaci žáků ve vyučovacím procesu, k posílení studijních i komunikačních kompetencí žáků a v neposlední řadě zvýšit atraktivitu vzdělávacího procesu HV, což je obsaženo i v hypotézách práce. Jejich potvrzení následně povede k modernizaci výuky Hv tvorbou dalších výukových materiálů. Nepotvrzení hypotéz povede k hledání dalších cest pro zkvalitnění a modernizaci výuky Hv.

Tabulka 6: Tabulka preferencí užití videozáznamu při hudebně – pohybové činnosti

	Pilotní skupina (14)	Výzkumný vzorek 1 (26)	Výzkumný vzorek 2 (26)
a) osobní prezentace před třídou bez záznamu	38	65	87
b) osobní prezentace před třídou s videozáznamem	47	73	98

c) prezentace videozáznamu před třídou	41	61	92
d) osobní prezentace pouze před učitelem	33	50	54
e) videoprezentace pouze před učitelem	21	41	45

LITERATURA

Bertrand, Y. (1998). *Soudobé teorie vzdělávání*. Přeložil Oldřich SELUCKÝ. Praha: Portál.

Brezinka, W. (1996). *Filozofické základy výchovy*. Přeložil Ivan OZARČUK. Praha: Zvon, české katolické nakladatelství.

GRECMANOVÁ, H., & URBANOVSKÁ, E. (2007). *Aktivizační metody ve výuce, prostředek ŠVP.* Olomouc: Hanex.

HOLAS, M. *Hudební pedagogika.* (2004). Praha: Nakladatelství AMU, 2004.

KOLÁŘ, Z., & VALIŠOVÁ, A. (2009). *Analýza vyučování*. Praha: Grada, 2009.

PRŮCHA, J. (1997). *Moderní pedagogika*. Praha: Portál.

POLEDŇÁK, I. (2005). *Hudebně pedagogické invence.* Praha: Univerzita Karlova

SEDLÁK, F. et al. (1984). *Didaktika hudební výchovy na II. stupni ZŠ.* Praha: SPN.
SEDLÁK, F. (1990). *Základy hudební psychologie.* Praha: SPN.

STROUHAL, M. (2013). *Teorie výchovy: k vybraným problémům a perspektivám jedné pedagogické disciplíny*. Praha: Grada.

NÁVRH EXPERIMENTU A TECHNICKÉ NÁSTROJE PRO VÝZKUM ÚČINNOSTI MUZIKOTERAPEUTICKÝCH REHABILITAČNÍCH STRATEGIÍ S UMĚLE IMPLEMENTOVANOU KOMPLEXITOU FYZIOLOGICKÉHO TYPU

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Abstract

The experiment focuses on identifying new effective rehabilitation strategies for patients with neurodevelopmental disorders and neurodegenerative diseases which rely on the empirically confirmed effect of musical stimuli. The strategies are inspired by the studies of new rehabilitation methods designed by Nicholas Stergiou (Biomechanics Lab, University of Nebraska in Omaha), based on the signals that contain artificially incorporated physiological complexity (e.g. pink noise). The physiological signals of a healthy organism contain a certain degree of such complexity.

The central thesis is the assumption that disease is a result of reduction or absence of physiological complexity. Rehabilitation strategies should seek to restore it by exposure to musical stimuli into which physiological complexity has been artificially injected by changing the duration of individual bars, resulting in the resemblance between the final time line and the time line of RR intervals on ECG.

It was found out that building physiological complexity into MIDI files using our software is relatively easy. It was verified by the pilot study that the upper margin of the amplitude applicable in therapy is phc=0.5.

Keywords

neurodevelopmental disorders, neurodegenerative diseases, new rehabilitation strategies, physiological complexity of pink noise, software MIDI

Předmětem interdisciplinárního výzkumu je hledání rehabilitačních strategií, které se opírají o empiricky potvrzené působení hudebních podnětů u pacientů s neurologickými problémy a jsou motivovány studiemi průkopníka nových rehabilitačních metod Nicholase Stergiou (Biomechanics lab, University of Nebraska at Omaha) (Hunt, 2014). Ty jsou založeny na signálech (zvuk, vizuální podněty, dotekové podněty), které cíleně obsahují uměle zakomponovanou fyziologickou komplexitu (např. typu růžového šumu). Jde o to, že fyziologické signály (ECG, EEG, rytmus chůze) zdravého organismu vykazují jistou míru komplexity, tedy signál není ani příliš jednoduchý (třeba periodický), ale ani příliš náhodný (jako je tomu třeba u bílého šumu). Optimální míra komplexity se těžko kvantifikuje, přestože již dnes existuje několik nových matematických nástrojů jako například Multiscale Entropy Analysis (Costa, 2005), Dentrended Fluctuation Analysis (Kantelhardt, 2002). Tzv. růžový šum je náhodný signál s takovou frekvenční charakteristikou, že výkonová frekvenční hustota je přímo úměrná převrácené hodnotě frekvence. Tento typ šumu se překvapivě vyskytuje v mnoha biologických systémech – např. v rytmech srdeční aktivity, v činnosti lidského mozku, či ve statistikách sekvencí DNA (Pylkkänen, 1995). S biologickým stárnutím a s onemocněními dochází k poklesu fyziologické komplexity např. v dynamice srdeční frekvence, dýchání, či chůze (Manor, 2010), což je aspekt, který výrazně koresponduje se záměrem výzkumu.

Jedním z nabízejících se přístupů je zakomponovat poruchu podobnou růžovému šumu do částí hudebních děl, které budou využívány při terapiích a edukaci. Potenciál využití takto upravených podnětů by mohl být velmi široký. Uplatnění je zřejmé všude tam, kde je empiricky doloženo působení muzikoterapeutických metod – u pacientů s neurodegenerativními onemocněními, ale i u dětí, které trpí neurovývojovými poruchami, jako je ADHD, u kterých se běžně využívá metod skupinové edukační muzikoterapie, a dále u dětí s poruchou autistického spektra, jimž tyto metody usnadňují orientaci v čase, prostoru a posloupnosti aktivit.

VYTVOŘENÍ SOFTWARU

Zásadním momentem je vytvoření know-how, jak obohatit záznam hudby v MIDI formátu o fyziologickou komplexitu.

Nejpříznivější pro naše potřeby je formát MIDI, který obsahuje časový záznam jednotlivých ‘events‘ (událostí). Událostí se rozumí například začátek tónu, konec tónu, stisknutí pedálu. MIDI záznam může obsahovat více stop. Práce s formátem WAV je také možná, ale technicky natolik náročná, že přesahuje naše možnosti.

Protože chceme pracovat se záznamem, který obsahuje poměrně málo stop, zvolili jsme klavírní skladbu. Tento nástroj je pro nás příznivý, co se týče průběhu dynamiky tónů (jasná ataka a rychlý útlum). Nezanedbatelný je také fakt, že existují velice kvalitní klavírní samply, což je důležité, protože jinak by se probandi soustředili na nepřirozeně znějící zvuky nástrojů a nebyli by schopni tento rušivý vliv odlišit od rytmických anomálií.

Vzhledem k pravděpodobnému výběru cílových skupin byla zvolena průzračná a optimisticky laděná Mozartova Sonáta facile (**Piano Sonata No. 16 in C major**, K. 545) (Databáze midi souborů, 2016). MIDI formát obsahuje čtyři stopy (kanály), jednu pro záznam tempa, jednu pro levou ruku, jednu pro pravou ruku a jednu pro ‘controller‘, v našem případě pravý pedál. MIDI je tedy kvantizované (tempo je strojově přesné), ale první stopa obsahuje jeho modulaci tak, aby nahrávka zněla přirozeně.

Rytmicky důležitější je stopa pro levou ruku. Nejprve je třeba narovnat rytmus tak, aby byl zcela pravidelný. To děláme proto, abychom měli pod kontrolou, jaký typ rytmické poruchy chceme použít. To je v tomto případě zcela triviální, protože stačí ignorovat první stopu, která obsahuje modulaci strojově přesného tempa. Ostatní stopy jsou již takto rytmicky srovnány (kvantizovány). Pokud nahrávka srovnaná není, je potřeba ji kvantizovat. Náš software (napsaný v MatLabu) provádí srovnání následovně: Ve stopě pro levou ruku vybere všechny ‘events‘ typu ‘note_on‘, které mají nenulovou hodnotu, tedy odpovídají začátku tónu (‘events‘ typu ‘note_on‘ s nulovou hodnotou znamenají konec tónu). Spočítáme rozdíly mezi následujícími ‘events‘ a najdeme základní délku (v našem případě odpovídá šestnáctinové době). Všechny souzvuky (‘events‘ v téměř stejném čase) srovnáme na stejný čas a všechny intervaly srovnáme tak, aby byly násobkem základní délky. Může se stát, že některý interval příliš vybočuje z osnovy násobků základní délky, patrně se jedná o ozdobu, triolu… Tyto ‘events‘ nazveme zvláštními a prozatím je necháme beze změny.

Poté, co je základní rytmus levé ruky srovnán, je třeba tomuto srovnání přizpůsobit pravou ruku, controller, zvláštní ‘events‘ v levé ruce a jakékoliv další události v MIDI obsažené, což provedeme prostou lineární interpolací. Předpokládejme například, že čas tří následujících událostí byl [100 110 150], kdy první a třetí událost je tón levé ruky a prostřední událost je tón pravé ruky. Předpokládejme, že po srovnání bude mít první událost čas 105 a třetí čas 160. Čas prostřední události potom změníme na hodnotu x tak, aby (110–100)/(150–100)=(x-105)/(160–105). Takto interpolujeme všechny události ve stopě pravé ruky, stopě controlleru a dále zvláštní tóny ve stopě levé ruky a všechny další MIDI ‘events‘.

Tím dostaneme rozumně kvatizovanou MIDI nahrávku a je možné přistoupit k aplikaci rytmické poruchy s fyziologickou komplexitou na tento soubor. Pro naše potřeby jsme využili časovou řadu RR intervalů zdravého lidského srdce, kterou lze získat na platformě Physionet (PhysioNet, 2016). Časovou řadu jsme přeškálovali tak, aby průměrná délka RR intervalu odpovídala délce jedné šestnáctinové doby. Takto upravené řadě říkejme A. Jako řadu B jsme vzali posloupnost stejně dlouhých intervalů, každý o délce odpovídající jedné šestnáctinové době. Konvexní kombinace C = t*A + (t-1)*B potom odpovídá různé amplitudě poruchy s fyziologickou komplexitou. Pro t=0 kvantizovanou MIDI nahrávku nijak neměníme (všechny intervaly zůstanou přesně stejně dlouhé, amplituda poruchy je nulová) a pro t=1 měníme délky intervalů maximální mírou tak, že délka šestnáctinových dob odpovídá délce trvání úderů zdravého srdce (amplituda je maximální). Spojitým přechodem od t=0 k t=1 můžeme docílit jakoukoliv žádanou amplitudu poruchy s fyziologickou komplexitou.

Samotný algoritmus implementace fyziologické komplexity do nahrávek vypadá takto:

Vybereme stopu, která odpovídá levé ruce, jež je rytmicky důležitější a vybereme tóny, které odpovídají začátkům osminových dob. Začátky těchto „těžkých“ dob posuneme do času odečteného z odpovídajícího indexu výše spočtené časové řady C. Tím dostaneme zárodek nové stopy, která bude mít požadované množství fyziologické komplexity. Zbylé MIDI události levé ruky (konce tónů, lehké doby, ozdoby, trioly,…)jsou upraveny lineární interpolací, jak je vysvětleno výše. Takto interpolujeme všechny události ve stopě levé ruky, které neodpovídají tónům na těžkých dobách. Stejným způsobem (tj. lineární interpolací podle těžkých dob levé ruky) potom upravíme zbývající dvě stopy – pravou ruku a controller. Tento způsob úpravy jednak zajistí, že rytmus (daný těžkými dobami levé ruky) bude mít požadovanou fyziologickou komplexitu, ale také to, že se skladba nerozpadne v tom smyslu, že pořadí a relativní časové vzdálenosti ostatních MIDI událostí budou co nejrozumněji zachovány.

Takto upravené nahrávky (kvantizované a následně vybavené rytmickou poruchou různých amplitud) opatříme kvalitními klavírními samply (Program Logic Pro X).

PILOTÁŽ NAHRÁVEK

Pro dotazníkové šetření volíme poslech pěti nahrávek: kvantizované, humanizované a dále tří nahrávek, do nichž je implementována fyziologická komplexita. Volíme tři úrovně poruch – phc=0.4, phc=0.8 a phc=1.0.

Stanovíme hypotézu: Předpokládejme, že nahrávky s implementovanou rytmickou poruchou kterékoliv nabízené amplitudy neruší (tedy líbí se) a jsou vnímány kladně i co se týče rytmické přesnosti. Pokud lze hypotézu vyvrátit, měli bychom najít tu úroveň implementované poruchy, která poslech ruší. Předpokládejme, že kvantizovaná nahrávka bude označena respondenty za rytmicky nejpřesnější a humanizovaná nahrávka za tu, která se nejvíc líbí.

Na dostatečně kvalitní aparatuře a v kontrolovaných podmínkách jsme pouštěli skupině 50 respondentů upravené nahrávky tak, že každý z dobrovolníků slyšel pět očíslovaných ukázek vždy téže části skladby – kvantizovanou, humanizovanou a s různými amplitudami rytmického šumu, a to v náhodném pořadí, přičemž žádné dvě nebyly stejné. K jednotlivým nahrávkám bylo možné se vracet. Respondenti pracovali s instrukcí, aby se soustředili na rytmus, zároveň však byli upozorněni na fakt, že nesledujeme správnost odpovědi, ale subjektivní vnímání rytmu. Prvním úkolem bylo seřadit nahrávky podle přesnosti rytmu do číslované řady od rytmicky nejpřesnější nahrávky po rytmicky nejméně přesnou. Druhým úkolem bylo seřadit nahrávky do očíslované řady podle toho, která se respondentům líbí nejvíc až k té, která se jim líbí nejméně, přičemž se toto hodnocení nemusí vztahovat k přesnosti rytmu. Ve třetí a čtvrté otázce odpovídali respondenti na dotaz, proč se jim uvedená nahrávka líbí nejvíce a naopak, co je na kterékoliv z nahrávek ruší. Očekáváme, že pocit libosti přímo úměrně nesouvisí s přesností rytmu. Dále jde o to, abychom co nejvíce eliminovali jakékoliv rušivé vlivy v poslechu hudebních podnětů, které by mohly negativně ovlivňovat terapeutický účinek.

Výstupem statisticky zpracovaných dat bychom měli dojít ke zjištění, jaká intenzita poruchy je už slyšitelná, ale ještě neruší poslech, tedy se kterou nahrávkou budeme moci pracovat na terapeutických sezeních s pacienty v prvním stádiu Alzheimerovy choroby.

VYHODNOCENÍ DAT ZÍSKANÝCH PILOTÁŽÍ

Máme k dispozici odpovědi 50 respondentů. Všichni kromě jednoho jsou muzikanti amatéři. Všichni respondenti kromě sedmi z nich hrají na nějaký hudební nástroj, nejčastěji na klavír (25 respondentů), kytaru (13 respondentů), flétnu (13 respondentů; další nástroje jsou zastoupeny vždy u méně než deseti respondentů.

Jelikož chceme odfiltrovat rušivé vlivy, zjišťujeme důvody, které jsou příčinou toho, že respondentům v poslechu něco vadí;24 respondentů (téměř polovina) uvedlo, že je ruší nahrávka číslo 4 (phc=1.0); většinou udali důvod, který souvisel s rytmem (změny tempa, zrychlování, kulhání, nevyrovnanost, ...). 14 respondentů (tedy 28 procent) uvedlo, že je ruší nahrávka číslo 2 (phc=0.8), důvody taky většinou souvisely s rytmem. Nahrávka číslo 1 (phc=0.4) rušila jen 4 respondenty, dva z toho udali jako důvod rytmickou nepřesnost, dvěma se zdála moc rychlá. Nahrávka číslo 3 (kvantizovaná) rušila dva respondenty z nejasných důvodů. Nahrávka číslo 5 (humanizovaná) rušila taktéž dva respondenty.

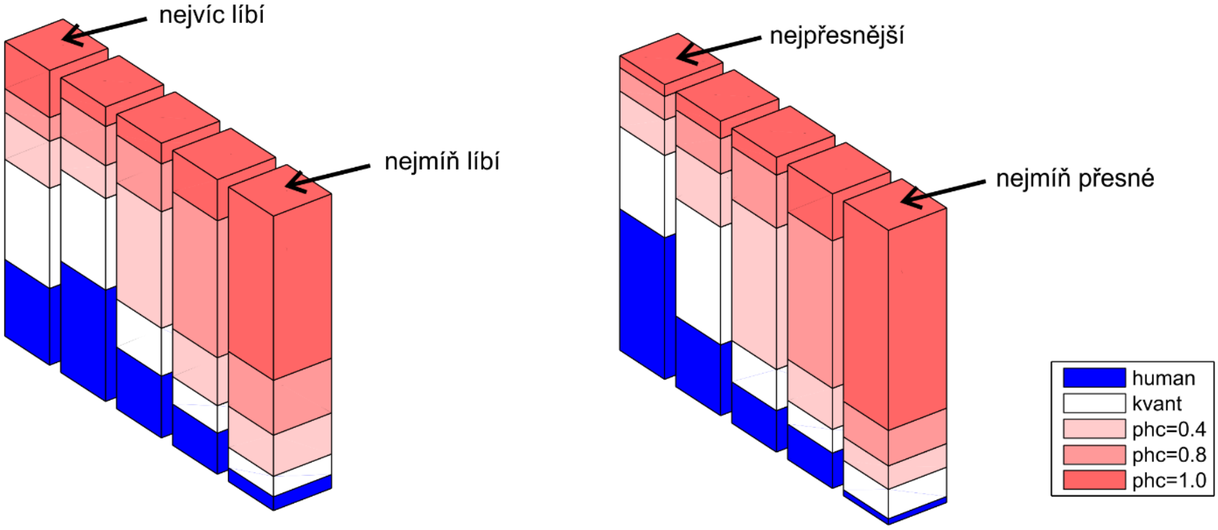
Zde lze tedy konstatovat že phc=1 je jistě moc velká amplituda, která ruší asi polovinu respondentů, phc=0.8 je taky za hranou (více než čvrtina respondentů ji neakceptovala), zatímco phc=0.4 je přijatelné. Pro terapeutický test volíme tedy phc=0.4 nebo phc=0.5. Kvantizovaná a humanizovaná nahrávka ruší jen velmi malé množství respondentů, což jsme očekávali (oba typy nahrávek se dnes běžně používají).

Ke shrnutí výsledků v otázkách seřazení nahrávek podle přesnosti rytmu a preference libosti jsme použili přiložený graf (libi-presne.png). V daném sloupečku je barevně označena proporce respondentů, kteří na tomto místě uvedli tuto skladbu. Například sloupeček „nejpřesnější“ má 48 procent modré barvy, to znamená, že 48 procent respondentů uvedlo, že jim nejpřesnější připadá humanizovaná verze. A tak dále. Nejvíce se respondentům líbí humanizovaná a kvantizovaná verze, obě vychází přibližně stejně. Nejméně se jim líbí phc=1.0.

Za nejpřesnější respondenti označují humanizovanou, nikoliv kvantizovanou nahrávku, což je překvapivé. Dále je pořadí jasné, pocitově druhá nejpřesnější nahrávka je kvantizovaná verze; dále se řadí phc=0.4, phc=0.8 a phc=1.0 ve správném pořadí.

Zajímavý je fakt, že je víc respondentů, kteří uvedli, že nejpřesnější je humanizovaná verze, než respondentů, kterým se humanizovaná verze nejvíc líbí.

V důvodech, proč se respondentům nejvíc líbí uvedená nahrávka, většinou rezonuje, že jim připadá přirozená a plynulá. V důvodech, co je ruší, se většinou uvádí rytmické vady.



- **Vysvětlivky**

human	humanizovaná verze
kvant	kvantizovaná verze
phc=x	úroveň fyziologické komplexity je x

ZÁVĚR

Využití hudebních podnětů s uměle zakomponovanou fyziologickou komplexitou je možné všude tam, kde dochází k poklesu fyziologické komplexity spojené s biologickým stárnutím a dále s neurovývojovými a neurodegenerativními onemocněními, u nichž byla prokázána účinnost muzikoterapie. Implementace poruchy fyziologického typu do vhodně volených hudebních podnětů se jeví jako přidaná hodnota, jež by měla být následně prokázána experimentálně v praxi.

Byl vytvořen software, pomocí něhož je možné implementovat poruchu fyziologického typu do hudebních děl ve formátu MIDI.

Pilotáží upravených nahrávek bylo zjištěno, že úroveň zakomponované poruchy, která respondenty neruší a je snesitelná, je phc=0.5. Na základě těchto výstupů bylo možné vytvořit konečný design experimentu, jenž však není součástí této studie.

SEZNAM POUŽITÉ LITERATURY A ZDROJŮ

AMBLER, Zdeněk. *Neurologie pro studenty lékařské fakulty*. 5. vyd. Praha: Karolinum, 2004. ISBN 80-246-0894-4. Str. 269-273.

ASHIDA, Sato. *The Effect of Reminiscence Music Therapy Sessions on Changes in Depressive Symptoms in Elderly Persons with Dementia* [online]. Journal of Music Therapy. 2000, **37**(3) [cit. 3.8.2016]. Dostupné z: https://doi.org/10.1093/jmt/37.3.170

COSTA, Madalena; GOLDBERGER, L. Ary and PENG, C.-K. *Multiscale entropy analysis of biological signals* [online]. 2005, **71** [cit. 20.12.2016]. Dostupné z: http://diana.mit.edu/physiotools/mse/papers/pre-2005.pdf

Databáze midi souborů [online]. [3.8.2016]. Dostupné z: http://www.piano-midi.de/midisearch.php?composer=14&formSubmit=Search&user=&count

Dementia Fact sheet. World Health Organization [online]. 2016, [cit. 30.7.2016]. Dostupné z: http://www.who.int/mediacentre/factsheets/fs362/en/

HARTL, Pavel a HARTLOVÁ, Helena. *Psychologický slovník.* Praha: Portál, 2000. ISBN 80-7178-303-X, str. 445.

BROADBENT, Donald E. *Perception and communication*. New York: Oxford University Press, 1987. ISBN 0198521715.

HUNT, Nathaniel; McGRATH, Denise and STERGIOU, Nicholas. *The influence of auditory-motor coupling on fractal dynamics in human gait* [online]. 2014, [cit. 30.7.2016]. Dostupné z: http://www.nature.com/articles/srep05879

JESENSKÝ, Ján. *Andragogika a gerontagogika handicapovaných*. Praha: Karolinum, 2000. ISBN 8071848239.

JONES, R. Mari; BOLTZ, Marilyn; KIDD, Gary. *Controlled attending as a function of melodic and temporal context* [online]. Perception & Psychophysics. 1982, **32**(211-218) [cit. 3.9.2016]. Dostupné z:

http://link.springer.com/article/10.3758/BF03206225

KANTELHARDT, W. Jan, et al. *Multifractal Dentrended Fluctuation Analysis of Nonstationary Time Series* [online]. 2002, [cit. 20.12.2016]. Dostupné z: https://arxiv.org/pdf/physics/0202070.pdf

MANOR, Brad; COSTA, Madalena; HU, Kun, et.al. *Physiological complexity and system adaptability: evidence from postural control dynamics of older adults.* Journal of Applied Physiology [online]. 2010, [cit. 20.6.2016]. Dostupné z: jap.physiology.org/content/109/6/1786

MÁTL, Ondřej a MÁTLOVÁ Martina. *Zpráva o stavu demence* [online]. 2015, [cit. 30.7.2016]. Dostupné z http://www.alzheimer.cz/res/data/002/000331.pdf

PhysioNet: the research resource for complex physiologic signals [online]. [3.8.2016]. Dostupné z www.physionet.org

POLEDŇÁK, Ivan. *Hudebně pedagogické invence: výbor ze studií a statí k hudební pedagogice a výchově*. Praha: Univerzita Karlova v Praze, Pedagogická fakulta, 2005. ISBN 80-7290-229-6.Str.68-69.

POSNER, I. Michael; SNYDER, R.R. Charles and DAVIDSON, J. Brian. *Attention and Detection of Signals*. Journal of Experimental Psychology: General. 1980, **109**(160-174) [cit. 20.7.2016]. Dostupné z: http://psych.hanover.edu/classes/Cognition/Archive/2009/Papers/posner%201980.pdf

PYLKKÄNEN, Paavo a PYLKKÖ Pauli. *New directions in cognitive science: proceedings of the International Symposium, 4-9 August 1995, Saariselkä, Lapland, Finland*. Helsinki: Finnish Artificial Inteligence Society, 1995.

ISBN 9512226456, str.280-285.

SACKS, Oliver. *Musicophilia: příběhy o vlivu hudby na lidský mozek*. Přeložila Dana BALATKOVÁ. Praha: Dybbuk, 2009. ISBN 978-80-86862-92-7, str. 325 – 337.

SACKS, Oliver. *Musicophilia: příběhy o vlivu hudby na lidský mozek*. Přeložila Dana BALATKOVÁ. Praha: Dybbuk, 2009. ISBN 978-80-86862-92-7, str. 326.

SIM, Roger. *Reminiscence: Social and Creative Activities with Older People in Care.* Speechmark Publishing Ltd, 1997. ISBN-13: 9780863884931, str.2.

Tests used in diagnosing dementia. Alzheimer's Australia [online]. 2008, [cit. 14.12.2016]. Dostupné z:

https://www.fightdementia.org.au/sites/default/files/helpsheets/Helpsheet-DementiaQandA10-TestsUsedInDiagnosingDementia_english.pdf

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