ICTE Journal

Volume 6 2017/3

International Journal of Information and Communication Technologies in Education

editorial

articles

ICTE Journal

International Journal of Information and Communication Technologies in Education

ISSN 1805-3726

Volume 6, 2017/3 (issued on November 30, 2017)

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Priorities of academic scholars with a limited amount of time

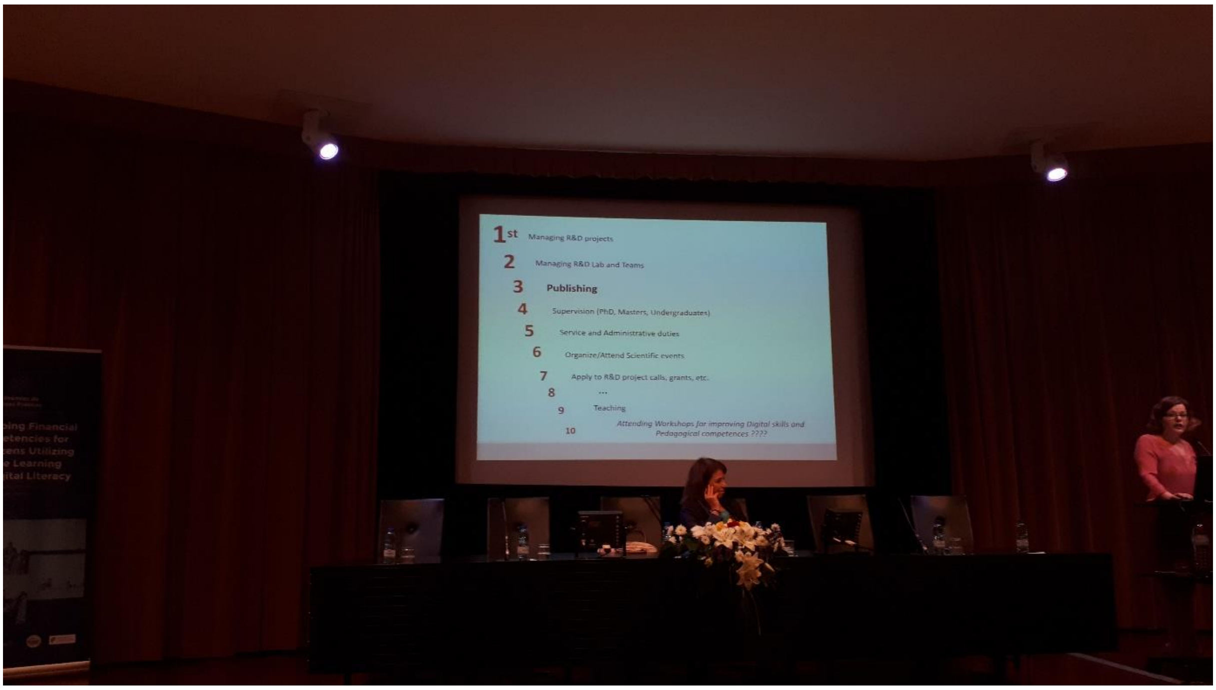
Dear colleagues,

Let me share with you some of the findings presented at the recent 2017 ECEL Conference in Porto, Portugal. International conferences are beneficial to us academic scholars for a number of reasons:

1. They allow us to learn about the work of our foreign colleagues – some of the papers may serve as an inspiration for our future research.
2. Unofficial and backstage conversations may result in forming a research partnership or collaboration on educational projects.
3. Such conferences offer us a glimpse at issues with which academic scholars at other universities have to deal.

Throughout the conference on eLearning, the most-discussed topic was the limited amount of time an academic scholar has to pass on their knowledge and skills to their students. Even in technology-based instruction, a teacher still needs to spend a sufficient amount of time not only creating instructional materials, but also preparing for the actual instruction. And even though ICT shortened the time that needs to be spent on those two key activities, for the majority of academics instruction still is not a priority.

Dr. Neura Pedro of the University of Lisbon presented the following list of an academic scholar's priorities:



She claims that research is high on the list because not only is it the main source of funds for a particular scholar or the entire institution, but also their reputation (while instruction is not). She supports this claim by presenting statistics on the University of Lisbon's publication record – one paper, monograph, proceedings paper or textbook is published every 7 minutes.

With the growing number of publication outputs, their quality decreases. The following numbers supports this claim:

- 6,000 – 7,000 academic papers are published every day. These numbers double every 5.5 years.

- 5% of the published papers contain 90% of all new information.

The presented numbers prove that this is a global problem. Publishing academic papers has become business for some publishers. There is a large number of so-called predatory journals which make money by charging publication fees.

On behalf of the editorial staff, I would like to ask both the current and future authors to submit their papers to journals that are published under the auspices of scientific institutions, such as the ICTE Journal.

We are glad that the aforementioned problem has not discouraged you from publishing your papers in the ICTE Journal and look forward to your future contributions.

Tomas Javorcik

Executive Editor

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ICTE Journal

2017, **6**(3): 5–13
DOI: 10.1515/ijicte-2017-0011

Native Development kit and Software Development kit comparison for Android applications

Arturo Mascorro[1], Francisco Mesa[2], Jose Alvarez[1] & Laura Cruz[3]

[1]*Polytechnic University of Victoria, 87138 Ciudad Victoria, Tamaulipas, Mexico*
{mascorrocienfuegos@gmail.com}

[2]*Autonomous University of Baja California, 21500 Tijuana, Baja California, Mexico*
{fmesa@uabc.edu.mx}

[3]*Technological University of Guanajuato North, 37800 Dolores Hidalgo, Guanajuato, México*
{laura_cruz_vazquez@hotmail.com}

ABSTRACT

A computational cost comparative study through both Java and C applications was developed. Computational routines consist of a matrix multiplications, the discrete cosine transform and the bubble-sorting algorithm. Memory and Runtime for each application were measure. It was determined that the runtime of matrix multiplication in Java was within the limits of 200 and 300 milliseconds, as opposed to the application developed in C, which shown to be stable with an execution period less than 20 milliseconds. In the ordering algorithm with the bubble method, it was observe that the Java language show be very slow compared to C. In addition, the memory usage was lower in most of the applications, showing a minimum difference. Applications were tested in both, a mobile LG- E510f and a Laptop Toshiba Satellite. The study allowed to report the profit generated in both runtime and memory consumption when performing a native implementation in C and Java.

KEYWORDS

Android, NDK, C Language, JNI.

1 INTRODUCTION

The Android operating system is widely used in several mobile devices such as Smart Phones and Tablets, probably because have a good performance, in addition to being very light.

Both, C language and Java are the programming languages that have managed to hoard the great and most of the programmers around the world. C-language is a strongly typed mid-level language, but with many low-level features. It has the typical structures of the high level languages but, at the same time, it has constructions of the language that allow a control to very low level (Kernighan 1998). The Android software architecture can be subdivided into five layers: core, low-level tools, native libraries, layer macros and runtime (Kyu 2011).

Java technology is characterized by being a multi-platform programming language, interpreted by a virtual machine. In Java distributions is not only the compiler, but also a virtual machine that allows you to run programs on any platform. Java is a high-level object-oriented programming language. The language itself takes much of C++, COBOL, and Visual Basic syntax, but it has a simpler object model and eliminates low-level tools which often induce many errors, such as direct manipulation of pointers or memory. The memory is managed by a garbage collector (Tauro 2012).

Companies that manufacture mobile devices have adopted this operating system to use it in their devices. Currently there are a large number of applications, most of which are developed in Java, probably due to the benefits it presents. For example, its cross-platform feature is very useful for developing applications for mobile devices; but since it is an interpreted language, it tends to be slower. This is a limitation for devices that do not have good resources.

There is the possibility of developing applications using a lower level Java language, which is the C language; this, to facilitate a greater control on the resources of the device, since new applications could be made with a better performance, reusing or creating libraries in language C. Working with C-language on Android increases the complexity and workload for the developer (Descamps-Vila 2011). Although it is feasible to reuse C libraries, sometimes modifications have to be made depending on the architecture with which it is being worked, and it would have to be compiled or recompiled for the different devices to which the application is directed.

Native Android Development Kit (NDK) is a set of tools that allows integrating components that make use of native code in your Android applications (Ki-Cheol 2011). Android applications run on Dalvik's virtual machine. The NDK allows to implement parts of your applications using native code, such as C and C ++ languages. This can provide benefits to certain classes of applications, in the form of existing code reuse and in some cases higher speed.

NDK is a great tool for the Android Software Development Kit (SDK) to combine the power of native x86 codes with the graphical interface of an Android container application (Cheng-Min 2011). While the tool can be used to gain performance benefits in some applications, a certain caution should be taken. For example, if the native library consists of an online assembler in the C code, the code can not only be mounted and worked "as is" in the two different architectures, and some modifications will be necessary (Palmieri 2012). This brings some benefits such as the re-use of code already implemented, or the possibility of developing applications that need to be more aware of memory management; such as a video-call.

The NDK consists of four parts; the first one includes the set of tools and compiled files that allows to generate the code in C or C ++; secondly, how to include native libraries in an apk; thirdly refers to the native headers or headers supported; and end part is the documentation, examples and tutorials. Although it is possible to develop in this way, there is a part of every application that must be written in Java. And to connect everything, a Java Native Interface (JNI) is used, which is designed to handle situations in which they need to combine Java In applications with native code. As a two-way interface, the JNI can support two types of native code, such as native libraries and native applications (Liang 1999).

While the Java programming language is of the secure type, native languages such as C or C ++ are not. As a result, should use special care when writing applications that use the native Java interface. A native method of bad behavior can corrupt the entire application. For this reason, Java applications are subject to security controls before invoking functions. As a general application rule, native methods are usually defined as few classes as possible. This implies a cleaner isolation between the native code and the rest of the application.

The objective of this article is to perform a series of comparisons between different routines executed in C-language and Java. Applications were tested on a LG-E510f mobile device and a Toshiba Satellite Laptop. Routines consisted of a 100 X 100 matrices multiplication, the discrete cosine transform, and the bubble sorting algorithm, with which the execution time and the memory usage in the application are measured.

2. MATERIAL AND METHODS

The methodology used to evaluate the development of mobile applications consist of comparing two programming languages, running different applications in each of them, using Android NDK and SDK. The development of the work was based on the execution of the different applications, such as the multiplication of matrices or the ordering of bubble, as well as in the behavior of programming languages "C" and "Java".

C is a fast and compiled language, but with slow interpreted; while Java is a half compiled language, with half interpreter. That is, Java needs a previous compilation to be able to run in its interpreter Java Virtual Machine (JVM). A LG branded model E510f (LG Electronics, Inc., Seoul, South Korea), with an Android operating system, version 2.3 Gingerbread, with Qualcomm MSM7227T 800MHz processor, Adreno 200 GPU and 512 MB of memory RAM, for the development of the tests, were used. It included a Toshiba Satellite A205-SP5822 Laptop (Toshiba America Information Systems Inc., China) with 2 GB in RAM and a Pentium Dual-Core processor at 1.86GHz.

Multiplication of 100-percent matrices filled with double-type random numbers was the first test performed. It's area which is commonly used in digital image processing. Program was developed in both Java and C languages. Table 1 shows an example of how operations were performed in both languages. The second application consisted in performing the discrete cosine transform of a 16 x 16 matrix. These matrices were loaded with random numbers of double type, commonly used in the compression of data and images (Lam 1998 and Strang 1999).

The discrete cosine transform (DCT) is an invertible linear function, often used in signal and image processing, especially for loss data compression. The action of the DCT can be described in terms of a transformation of matrix A of type:

$$Y = AXA^T \tag{1}$$

where X is a sample matrix, Y is a coefficient matrix and A is a transformation of an $N \times N$ matrix. A-elements are represented by:

$$Y_{xy} = C_i \frac{(2j+1)i\pi}{2N} \tag{2}$$

with C_i represented by equation 3:

$$C_i = \sqrt{\frac{1}{N}}(i = 0), \quad C_i = \sqrt{\frac{2}{N}}(i > 0), \tag{3}$$

Calculating formula for discrete transform of the two-dimensional cosine can be visualized in the equation:

$$Y_{xy} = C_x C_y \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} X_{ij} \cdot \cos\frac{(2j+1)y\pi}{2N} \cdot \cos\frac{(2i+1)x\pi}{2N} \tag{4}$$

which is complemented from the data of the recorded matrix in Table 1. Discrete cosine transformation is shown in Table 2, and presents the same dimensions as the matrix of Table 1. It can be observed that the major values are in the triangular upper-left part of the matrix.

Finally, the ordering algorithm was obtained by the bubble method with a 1000 test data randomly filled with numbers from 0 to 99; this to visualize the time in which a certain amount of data in each language is ordered. For development with the NDK, program was generated with the language in Java (Activity, Service), then the folder where the files were created in language C and a file called Android.mk. Applications measure runtime and usage of your routine memories in the "C" and "Java" languages both on the mobile device and on a PC.

3. RESULTS

The first test consisted in multiplying two 100 X 100 matrices, which were filled at random with double type data. Performing 32 routines in both applications, it was observed that the C language in this device proved to be faster to perform the multiplication of matrices.

Making a Box Diagram (Figure 1) it can be observed that the execution time of the multiplication of matrices in Java was within the limits of 200 and 300 milliseconds, as opposed to the application developed in C, which remains stable with an execution period below 20 milliseconds.

31	23	60	93	49	57	57	35
31	21	74	73	55	52	45	44
25	16	82	65	61	38	50	51
26	38	91	61	62	28	49	50
17	85	70	76	50	34	37	43
29	90	68	53	43	25	30	49
116	184	108	25	52	26	38	36
151	144	182	129	44	23	41	39

Table 1: Test matrix for DTC calculation

The second test was worked with the discrete cosine transform. The results obtained in Java showed an average of 247 milliseconds, while in C its average was of 6 milliseconds (Figure 2). In the bubble method ordering algorithm it can be observed that the Java language is extremely slow to perform the ordering, in comparison with the C language. Figure 3 shows the behavior of the execution time of the two routines. In the routine programmed in Java the average runtime is 12,128 seconds and the average runtime in C is 2.9 milliseconds. The results obtained show a comparison regarding the use of the Memory in the applications.

466.25	100.9063	-40.3393	-91.1315	-25.25	2.6791	-3.3152	16.6482
-88.4065	-146.066	-67.5059	26.1243	33.412	44.3008	24.6658	-0.4861
69.5604	73.4218	17.6909	8.1087	-1.2285	31.3229	12.3824	-7.9303
-44.0839	-28.5187	4.3866	18.4638	-11.9507	-32.162	-31.1853	-32.1898
27.5	12.2552	-25.4491	-19.8833	9.5	35.2306	3.2352	-10.1438
-2.2299	6.377	26.7637	18.3775	-13.4471	-20.9802	-10.1116	19.2261
-10.4122	-22.5187	-20.8676	-15.9436	17.2859	25.742	9.5591	-4.747
8.0193	11.5534	7.5823	9.4544	-9.8801	-12.0629	-13.257	-7.4175

Table 2: Transformed Matrix

Figures 4, 5 and 6 shows that the use of memory in the bubble ordering mobile device for C language is less than that used in the Java programming language. Although the difference is minimum 6.94%, this behavior shows be very similar in the case of the discrete cosine transform, except in the shared memory, since this is used more in the C language.

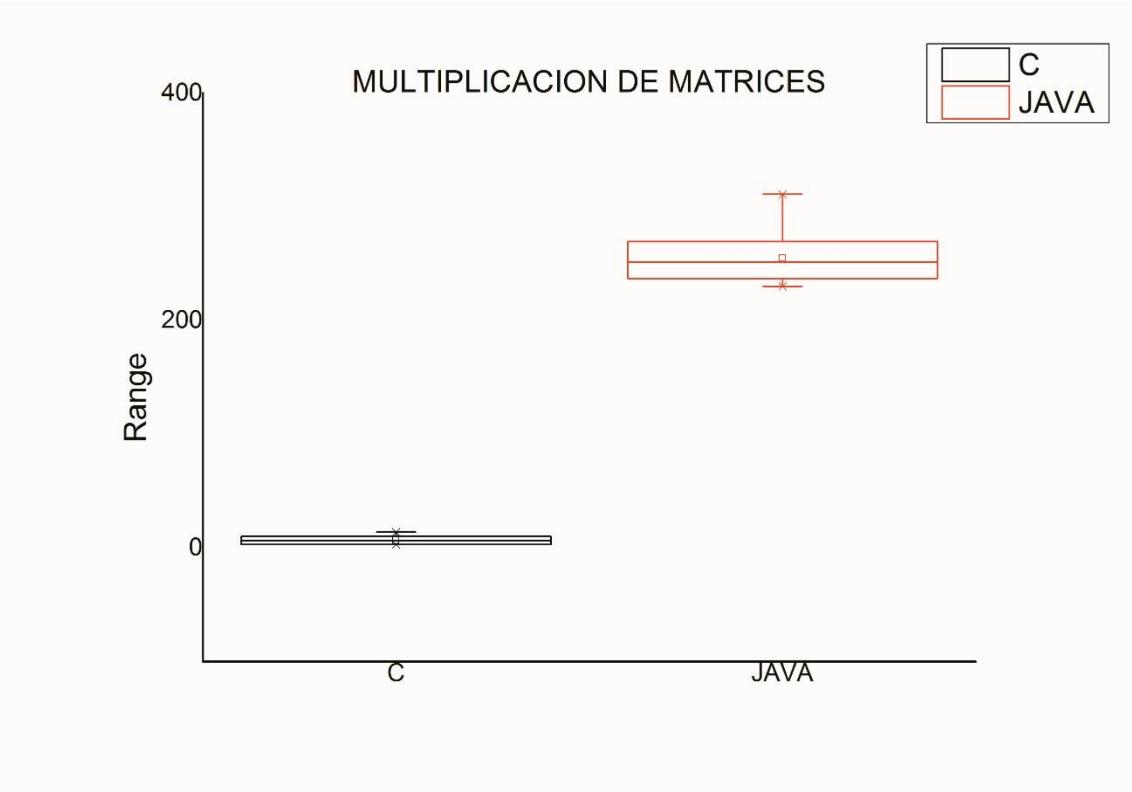

Figure 1. Runtime matrix multiplication on a mobile device.

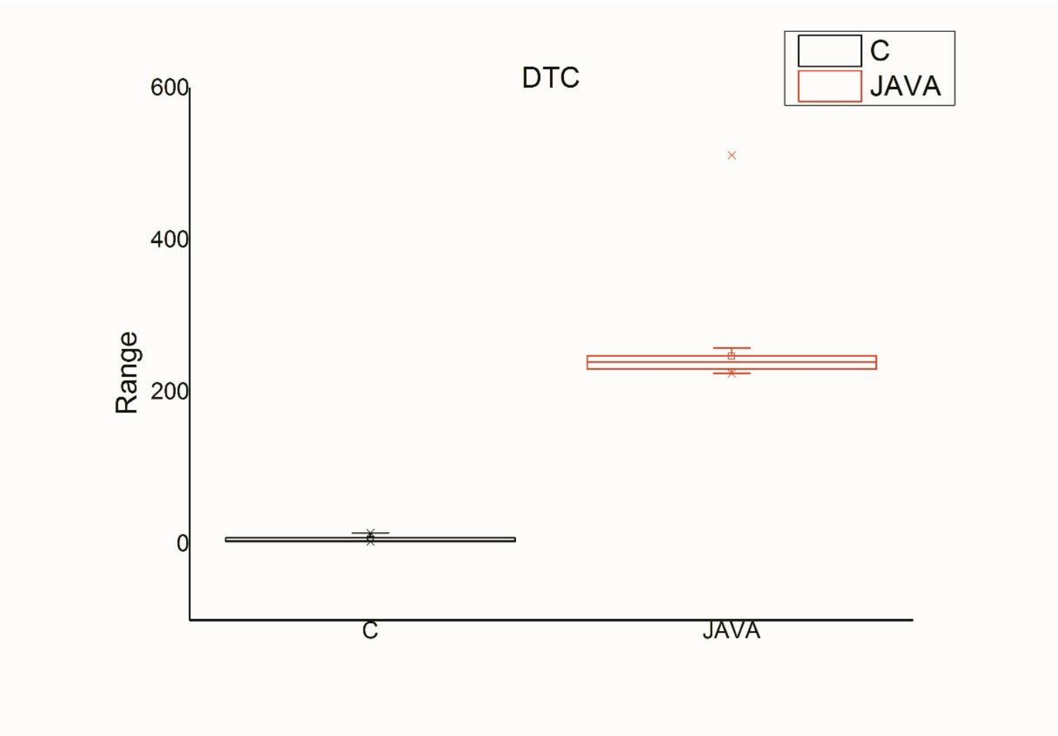

Figure 2. Runtime in the application of discrete cosine transform.

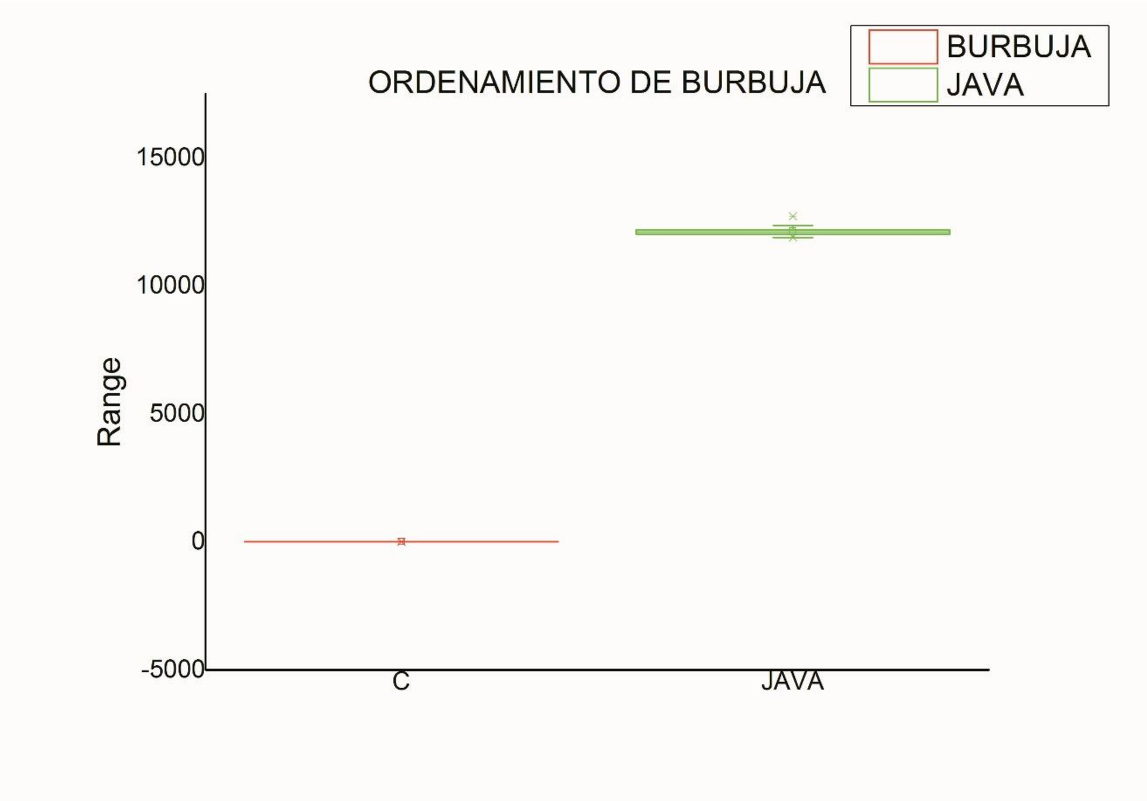

Figure 3. Runtime sorting algorithm on the bubble method in milliseconds.

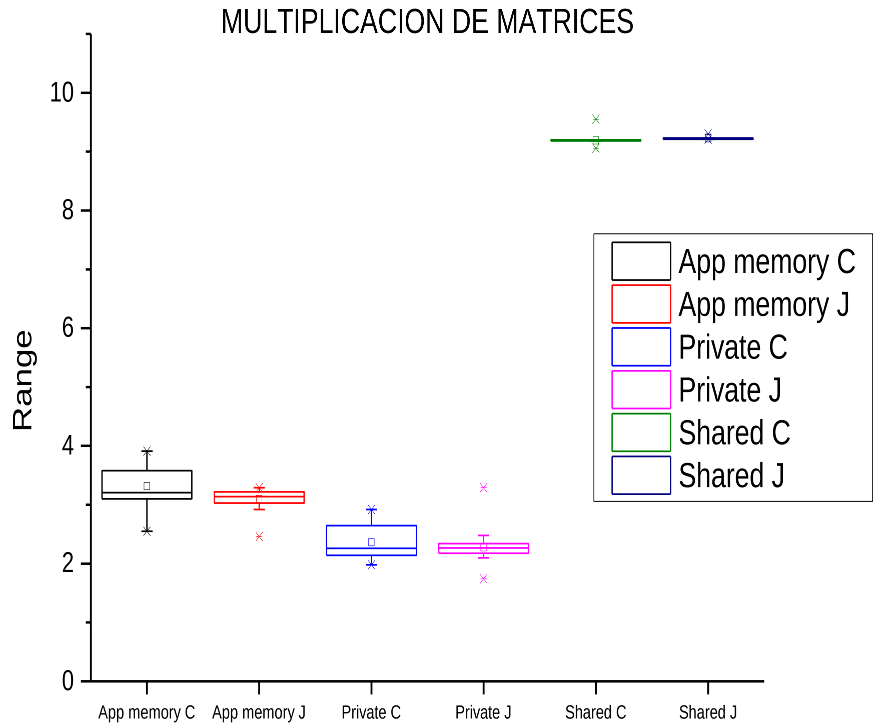

Figure 4. Memory use in implementing matrix multiplication.

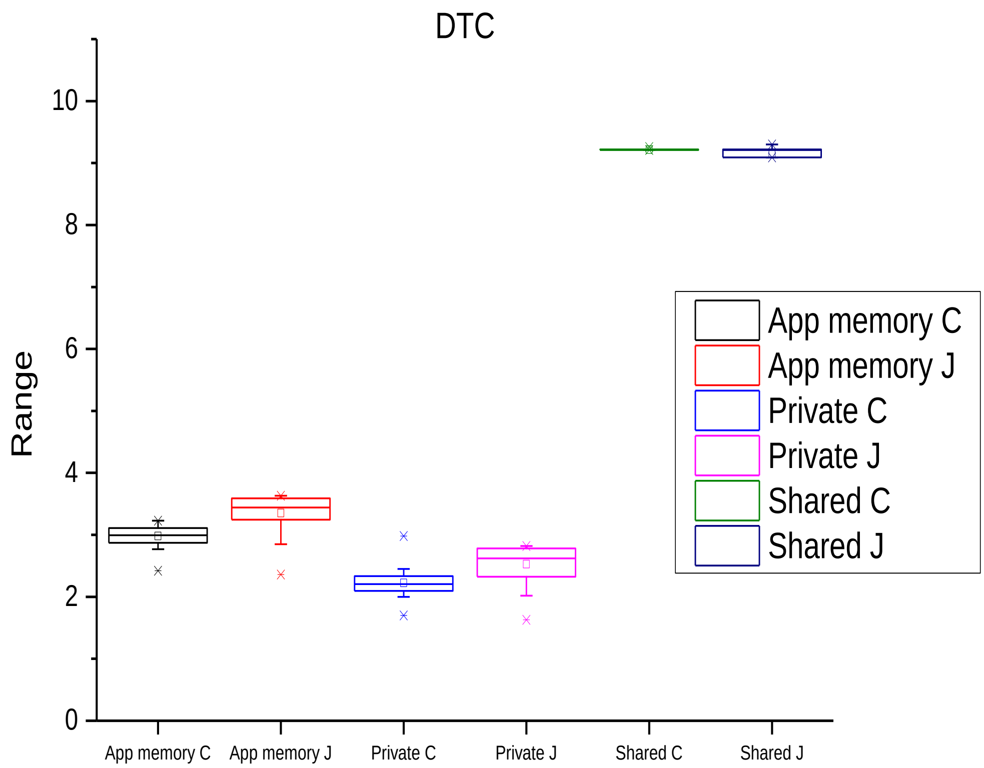

Figure 5. Memory use in the application of discrete cosine transform.

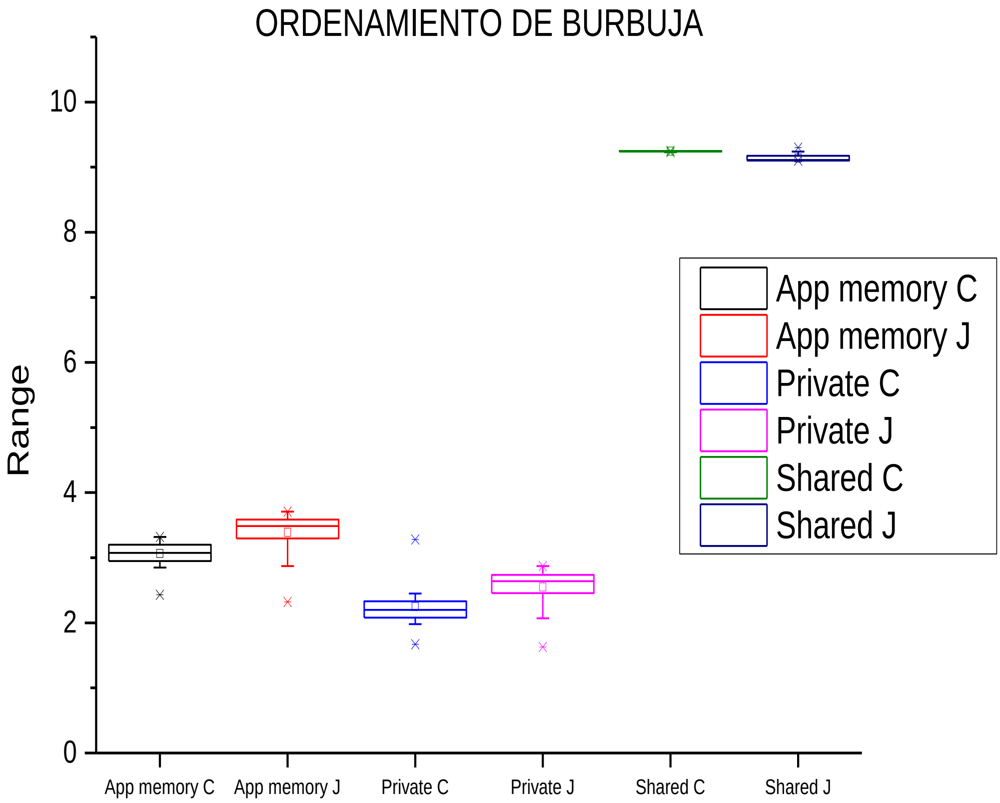

Figure 6. Memory use in applying bubble sort.

Finally, it can be observed in multiplications of matrices, that the use of memory in the C language is wider, with respect to Java.

4. CONCLUSIONS AND DISCUSSIONS

A methodology based on the comparison between different routines executed in C language and Java was presented. Applications were tested on a LG-E510f mobile device, as well as on a Toshiba Satellite Laptop.

In the first test that was performed, it was observed that when working with arrays a greater execution speed of 97.45% is perceived with C programming language. In the second test, in which was worked with the discrete cosine transform, less time was recorded in the "C" language execution, compared to 95.5% Java.

With bubble sorting, the execution time in the Java language had an average of 12.17 seconds being considerably slower when performing this type of operation compared to the "C" language, with a runtime 77.5% faster than Java. These results suggest that the runtime on a mobile device with 800 MHz Qualcomm processor is faster compared to the Android NDK. This is a goodness that offers the C language to be able to develop applications that require a greater number of operations and with the possibility of accessing the devices of the mobile, for example the video camera, accelerometer etc. Doing so in this way increases the difficulty of programming, taking into account that a bad code can damage the entire application or generate unexpected results. In addition, because it is no longer fully available with the benefits of Java, it would have to compile or recompile the code to work on different architectures.

The use of memory in applications is extremely important, so as not to affect the performance of the mobile device. It should be mentioned that when working with the native Android environment, a part of the application is built on Java. This advantage provided by the programming language "C" is used to improve the applications of the mobile devices that require a higher information processing, as it is the video compression or the encryption of the information; these programs use several mathematical functions that require a lot of calculations. The results obtained will help the programmer to have a greater visibility of the tools that can be used at the time of realizing their programs.

ACKNOWLEDGMENTS

The authors wish to express appreciation to the Mexican National Council of Science and Technology (CONACYT), for total support to carry out this study.

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ICTE Journal

2017, **6**(3): 14–25
DOI: 10.1515/ijicte-2017-0012

ICT COMPETENCIES FOR ACADEMIC E-LEARNING. PREPARING STUDENTS FOR DISTANCE EDUCATION - AUTHORS' PROPOSAL

Barbara Kołodziejczak [1], Magdalena Roszak [2]

[1]Department of Computer Science and Statistics, Medical Faculty II, Poznan University of Medical Sciences, Dąbrowskiego St. 79, Poznan, 60-529, Poland {bkolodziejczak@ump.edu.pl}

[2]Department of Computer Science and Statistics, Medical Faculty II, Poznan University of Medical Sciences, Dąbrowskiego St. 79, Poznan, 60-529, Poland {mmr@ump.edu.pl}

ABSTRACT

Deployment of distance education (especially 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 competencies of a secondary school graduate. On the basis of a research project conducted at three medical universities in Poland, the authors present the level of knowledge and practical skills in the field of ICT among students who participated in e-learning or blended learning. As a result of the project, a proposal has been presented for modifying ICT education contents for students, as well as a draft course carried on the university's LCMS (Learning Content Management System) portal to bridge the ICT competence gaps for effective distance education.

KEYWORDS

ICT competences, ICT training, e-learning, academic education, distance education, school education system, e-learning technologies

1 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; Roszak, Kołodziejczak, Kowalewski, & Ren-Kurc, 2016a). 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, Roszak, Kowalewski, & Ren-Kurc, 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., 2016a; Roszak & Kołodziejczak, 2017). Preparation of IT (Information Technology) 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, Roszak, Kowalewski, Ren-Kurc, & Bręborowicz, 2015; Malach, Kostolányová, & Chmura, 2015; Noskova, Pavlova, Yakovleva, & Sharova, 2014; 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., 2016b). 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.

2 ICT COMPETENCIES OF DISTANCE LEARNING PARTICIPANTS VS. TECHNOLOGIES

Contrary to certain opinions regarding the dawn of LCMS distance learning portal applications in the organization of distance learning, they still remain the primary tools, indispensable both for students and for teachers. An LCMS portal application, regardless of the technology applied, will always support the WWW server software responsible for online publication over the Internet. At the moment, an educational organization is not required to have its own independent IT infrastructure - machines, personnel or space. The entire application can be maintained in a computing cloud. This is a paid option for renting hardware working time and IT service. The choice between the cloud or own infrastructure must be reviewed by economists. However, regardless of the economy, the following must always be installed on a physical or virtual (cloud) server machine:

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

This does not necessarily involve financial investments - all the above specified applications and technologies are available as freeware or open-source products under GNU General Public License. When planning for implementation of freeware solutions, the architectural limitations must be checked in the application documentation. 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., 2016a).

The most important feature of LCMS portal application for distance learning is the unique data processing mode: the application is launched from a Web browser, and therefore there are no restrictions regarding the PC workstations to be used for working with the portal. The only prerequisites are: connection to the Internet, and any WWW resources browser. It should be noted here that browsers on smartphones are simpler applications than their PC counterparts. LCMS portals often generate special operator interfaces designed for smartphones. To elaborate on the subject, a separate paper would be necessary, devoted to m-learning.

The URL (Uniform Resource Locator) linking to the Web server resources supported by the LCMS application needs to be entered manually in the browser for the first time; then, it will be prompted automatically to the user. The character string entered by the user is analyzed by the machine, without context. Any error, misspelling etc. would cause the browser to generate an error message. Passive understanding of the subsequent stages of automatic communication between the browser and other network applications is extremely useful in an attempt to understand such message. It would be hard to imagine a user contacting IT personnel about any message displayed on their screens, particularly when there are hundreds of portal users (learning participants) requiring instruction. 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.

The phrase “Internet technologies” is used to describe a broad and continuously expanded set of technologies identified by officially registered descriptions for streamlining software developers’ work and machine communication. This is an essential aspect of ICT education for distance learning participants: you must absolutely follow all standards and limitations imposed by these standards. These include:

- 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.

Thus, a question emerges whether a secondary school graduate (future university student) or a university graduate (future university teacher or administrative employee) is well prepared to function as a distance learning participant (particularly with regard to academic e-learning). It should be mentioned that more advanced ICT background of technical university students is related rather to their private hobbies or interests than to their school background.

Further into the article, the authors review the competences of a secondary school graduate (potential university students) and compare them with the ICT competences required of a distance learning participant.

3 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. According to the school syllabus, development of IT education is based on the assumption of expanding computer literacy with the skills which facilitate adaptation to the changing technologies, proficiency in using information and communication technologies, and computational thinking.

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 (Kołodziejczak & Roszak, 2017). 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

Teachers' professional background and adaptation of syllabuses to rapid technology advancement is a great challenge for education authorities. Advanced courses organized by the local Teacher Training Divisions are not sufficient to ensure adequate quality of teaching information technology. The teacher needs to be passionate and committed to improve his or her competences independently and to be able to follow the rapid changes in the field of information technologies. Also, the currently prevailing trend in primary and secondary school system towards combining competences in teaching more than one subject, e.g. mathematics and informatics, has an adverse effect on the overall level of teaching. 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.

In 2017, the Polish school system underwent another reform in terms of organization and syllabus. The new syllabus for the school subject called *informatics* puts a special emphasis on teaching students how to think in algorithms and on learning programming, starting with education stage II (grades 4 through 8 of primary school). This is the level of education to which the authorities have moved the objective of development of problem-solving and decision-making skills using a computer, following the algorithmic approach, previously implemented at stages III and IV of the education system. The remaining goals and contents of competence-oriented learning in the field of information and communication technologies, which are differently phrased and often presented in more detail, are generally consistent with the previous syllabus (What's new in teaching computer science in a new elementary school?, 2017). The issue of improving ICT competences to the extent necessary to engage in distance learning still remains unresolved to a certain extent.

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.

4 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 asked 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 (Kołodziejczak & Roszak, 2017). 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, Kowalewski, Roszak, & Kołodziejczak, 2012).

Problems

Category A – 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 – *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.

5 LEARNING CONTENTS FOR ACADEMIC E-LEARNING - AUTHORS' PROPOSAL

Part 1: Proposal to broaden the learning contents of Information Technologies courses offered to university students

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 prepare students to function as a conscious recipient of e-learning, their knowledge and skills should be developed to the extent to which they are necessary for using learning portals and other resources made available online. This would require updating the syllabus of the *Information Technologies* subject, which is classified as obligatory in most faculties. Here are the key areas of ICT competence development for students, particularly in humanities, economy, social studies, nature and medical science:

1. *Online communication methods, basic security principles for people using or sharing resources over the Internet.* Students' knowledge in this field is usually very limited, which can be demonstrated e.g. by personal account sign-in data memorized by Web browsers in public places; ending work with a portal without logging out; inability to interpret security certificate messages generated by browsers.
2. *Handling multimedia and interactive materials*. Despite that the use of YouTube site resources is common, the students' understanding of streaming or lack of such technology is at a very low level.

Their knowledge regarding audio/video stream encoding, which would help them understand problems with playing video or audio materials, is also very limited. Installation of a multimedia plug-in in an online browser exceeds the range of competence of an average student at a non-technical university.

3. *Synchronous and asynchronous communication tools, group work tools*. Group communication is an important component of distance learning, whether realized as e-learning or blended-learning. Students have no problems operating common messenger applications, such as chat, forum or e-mail. On the other hand, the ability to operate such group work tools as Wiki, a virtual board, or sharing resources from Google app is not common.
4. *Copyright protection and applicable laws*. The availability of resources in the global network is not associated with knowledge of copyrights and current copyright legislation. Students usually have little knowledge of the restrictions imposed on the user by licenses based on which resources from private or commercial websites are shared, or licenses for purchased software.

If the learning contents and skills are expanded with the matters discussed above, it will become easier for students to use the most advanced education support technologies and to safely operate the resources and tools helpful in the learning process, including distance learning.

An alternative to the above is to prepare a course offered at a university, to give students proper qualifications to participate in the various distance learning options.

Part 2: Distance training - a proposal for expanding the academic e-learning contents

In order to acquire knowledge of online tools and operating Internet applications in the course of academic education, and to develop optimized distance multimedia learning service user skills in the recipients of such education requires appropriate ICT competences. These can be improved through offering future knowledge recipients participation in 30-hour distance course, presenting the fundamentals of e-learning technologies and preparing them to participate in the learning process with the involvement of new technologies.

The subject-matter of such training must primarily present the perspective of an e-learning user; therefore, in order to prepare the training, adequate examples and practice will have to be created. Duration of training will depend on the participant's knowledge and skills in the field of ICT, ranging from 15h to 45h. Students' own work is very important here, as it will take more time than the presented learning materials.

It should be borne in mind that in case of any problems with a specific topic or exercise, the e-teacher should extend the training contents by creating additional materials or examples to clarify the problem. Preparing learning materials for such a course is a major challenge, which should be thoroughly analyzed and designed properly.

Below is a presentation of topics for distance courses, divided into areas A, B, C and D in terms of ICT competences necessary for the receiving end of distance education, which was proposed by the authors in 2012 and became the basis for the data analysis in Section 4. The last topical unit - category E is the result of the authors' further research (The process of publication in Internet resources), allowing students to effectively publish their findings and results on an LCMS portal.

The topics of an *area A* (*Launching processes and applications*) distance learning course should include:

- Using the LCMS portal being implemented;
- Evaluation of students' knowledge: graded closed-end tests, self-tests, written assignments (text, graphics) graded by the teacher, project group work;

- Learning simulations and animations - using various types of interfaces;
- Virtual learning environments set up on the basis of various process simulation software (e.g. virtual laboratories) in various technologies;
- E-coursebook (examples).

The topics of an *area B* (*Understanding the flow of communication on the Internet with the discernment of the used services*) distance learning course should include basic knowledge of:

- The communications standards followed over the Internet;
- Functional limitations derived from the communication standards applied in the Internet;
- Role of the sign-up process in an online application;
- Publishing materials in Web server resources (this topic is designed only for individuals who are not following the unit: The process of publication in Internet resources).

The topics of an *area C* (*Knowledge of basic HTTP protocol communication client applications, commonly known as browsers*) distance learning course should include basic knowledge in the following fields:

- HTTP communication standards, e-mail service standard and HTML communication (forms, file transfer, etc.);
- Synchronous and asynchronous communication services over the Internet;
- Account privacy and data security issues.

The topics of an *area D* (*Installation and use streaming media client software, commonly known as multimedia*) distance learning course should include:

- Multimedia streaming via dedicated servers, with web browser software used as client;
- Encoding and decoding data streams in practice, standards implemented in the browser used as streaming client;
- Audio and video materials handling practice.

Pursuant to an analysis of any problems diagnosed in distance education participants, the authors suggest that the course topics further include topics which would enable students to publish the outcomes of their work e.g. in project group resources, or as e-portfolio. This type of course would be designed for more advanced users, and as such should be recognized in a separate *category E – The process of publication in Internet resources*.

The topics of an *area E* (*Process of publication in Internet resources*) distance learning course should include:

- Editing text files for publication in Web server resources;
- Editing multimedia files for publication, including encoding and conversion to various formats on students' workstations;
- Embedding multimedia in HTML5 files, to be published in Web server resources;
- Testing to validate the publication process.

CONCLUSION

Academic distance education (particularly e-learning) requires its participants to exhibit certain knowledge in the field of information technology, and to acquire certain skills which are often beyond the range of ICT competences learned earlier on the education path (from elementary to secondary school).

To eliminate the problems thus caused, the authors suggest the following two complementary solutions (Kołodziejczak & Roszak, 2017):

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 selected area 1–4 topics included in subject syllabus, students' competences could be improved and students themselves could be prepared to participate in various forms of distance learning offered by the university. This type of arrangement does not entail any additional expenses and is beneficial for students as well as the university.

Re: 2. Mandatory attendance at a distance course proposed by the authors in Section 5 – Part 2 would enable students to bridge the gap in their ICT competences and to be prepared for functioning efficiently as knowledge recipients in distance education. However, this type of arrangement involves extra costs for the university to prepare and facilitate the course.

ACKNOWLEDGEMENTS

The authors present their cordial thanks to the following staff members of the Polish Universities for their participation in the research project: Professor Andrzej Bręborowicz and Beata Maćkowiak, MSc (Department of Pathophysiology, Poznan University of Medical Sciences), Piotr Leszczyński, PhD (Faculty of Natural Science, Siedlce University of Natural Sciences and Humanities, and Collegium Masoviense in Zyrardow), Wiesław Półjanowicz, PhD Eng. (Faculty of Mathematics and Informatics, University of Bialystok).

Our special thanks and appreciation goes to Anna Ren-Kurc, PhD, at the Faculty of Mathematics and Computer Science, Adam Mickiewicz University in Poznan, for the support and professional assistance offered to us in the course of executing this research project.

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ICTE Journal

2017, *6*(3): 26–39
DOI: 10.1515/ijicte-2017-0013

IMPLEMENTATION OF FEEDBACK SUPPORTING FORMATIVE ASSESSMENT INTO MATHEMATICAL DIGITAL LEARNING MATERIALS

Stanislav Lukáč[1], Jozef Sekerák[2]

[1]*Institute of Mathematics, Faculty of Science, Pavol Jozef Šafárik University in Košice, Slovak Republic {stanislav.lukac@upjs.sk}*

[2]*Lifelong Learning Centre and Projects Support, Pavol Jozef Šafárik University in Košice, Slovak Republic {jozef.sekerak@upjs.sk}*

ABSTRACT

Official documents of educational policy of the European Union highlight the importance of integrating ICT into education. Interactive learning materials play an important role in the meaningful use of ICT to support an active learning. Providing feedback dependent on student´s actions should be a standard part of the digital learning materials. The 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 the digital learning materials independently in the classroom or at home. Moreover, ICT tools offer a great potential for detecting and eliminating students' mistakes. A notification of a concrete type of error in student's way of task solution and guiding students during the corrections of their solutions creates conditions for application of formative assessment which provides suggestions to students for improving their 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. Various forms of feedback should be implemented in the interactive learning materials in order to stimulate the active learning. In many available the digital learning materials there is often a minimal feedback provided on student´s solution of a certain task. This paper discusses the implementation of various types of feedback in an interactive mathematics learning environment. Even though the minimal feedback can stimulate the 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. The diagnosis of typical student´s misconceptions was based on the analysis of the results of the prepared tests, which were given to students at high school. Demonstrations of the minimal feedback and higher levels of feedback are illustrated in the examples of fractions, percentages and investigation of function dependencies. The interactive learning materials are developed using Geogebra and MS Excel.

KEYWORDS

Mathematics teaching, misconceptions, interactive learning materials, feedback, formative assessment, problem solving.

1 INTRODUCTION

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. The 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 (Žilková, 2009). The computer simulations are designed to facilitate teaching and learning through visualization and interaction with dynamic models (Sarabando, Cravlno & Soares, 2016). Innovative approaches to mathematics teaching are often based on independent inquiry of mathematical relationships (Koreňová, 2015). The inquiry-based learning fosters observations followed by experimentation, modelling, and justification of findings (Hähkiöniemi, 2013).

The effect of inquiry-based learning on acquisition of knowledge and skills and on the understanding of the learning content depends on many factors. Jeff C. Marshall identified in his publication (Marshall, 2013) the three most important factors:

1. Learning lessons stimulating an active students' inquiry. Designed research questions should engage students and should be appropriate to their knowledge and abilities. Marshall recommends to use the model 5E (Engage, Explore, Explain, Elaborate, and Evaluate) for the organization of the inquiry based learning.
2. Formative assessment. Some teachers consider the assessment as the final stage of teaching. However, the assessment may also include various processes implemented during the teaching and provide students stimuli to improve their learning.
3. Teacher's reflexion. Collecting and analysing information about the learning success and the deficiencies that have occurred during the lesson provide the teacher bases for the retrospective evaluation of the learning process and the teaching materials, eventually also for their corrections.

Better understanding of findings discovered during inquiry and their elaboration to student's internal knowledge system can be enhanced by the formative assessment (Keeley & Tobey, 2011). The basis of the formative assessment is the analysis and use of information from a variety of interactions between teachers and students to provide feedback to students in order to improve their further learning.

The success of the independent student investigation depends strongly on the selection of the research question and student motivation (Rocard, 2007). Kyriacou and Goulding (EACEA P9 Eurydice, 2011) declare that ICT can raise student motivation for the active investigation and learning. They describe some surveys in Europe focused on ways of the use of ICT in mathematics education. Some results show that the use of ICT at home for school relate work is still relatively low. The digital learning materials, in which are implemented various levels of feedback, can suitably support home learning activities.

2 DESIGN OF FEEDBACK IN THE INTERACTIVE LEARNING MATERIALS

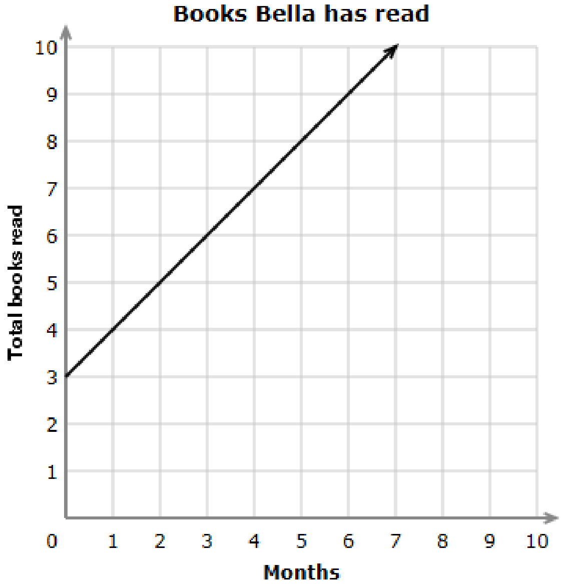
Feedback in the learning materials offers means for stimulation of an active learning. ICT can offer quick and contextual feedback providing students information on the correction of their results acquired through learning. Mathematics teachers have some resources of the digital learning materials available on the internet, such as The planet of knowledge, Maxi test, etc. Teachers can edit or create own learning materials in the both mentioned systems. Authors of various educational systems often pay little attention for providing of feedback. But implementation of monitoring and managing the learning and evaluation of results into the interactive learning materials is essential. In case of an 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 the learning materials can be implemented through several ways. McKendree (McKendree, 1990) sees main aim of feedback in the 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. This author distinguished three basic levels of feedback:

1. Minimal feedback: student gets only brief information about the correctness or incorrectness of his/her answer.

2. Condition violation feedback: in the case of incorrect answer student is advised on incorrectly applied a rule.
3. Goal feedback: the information for student is formulated in such a way that it should help him/her to find the correct solution. Student is informed about requirements which are necessary for elimination of the mistake in next work.

Conclusions of research performed by Perrenet and Groen (Perrenet & 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 actions for the required solution method. Better educational content acquisition and increasing of chance to thoroughly learn and master curriculum require to clarify problematic issues of a particular curriculum (Prextová, 2015). 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.

This graph shows how the total number of books Bella has read depends on the number of months she has been part of a book club.



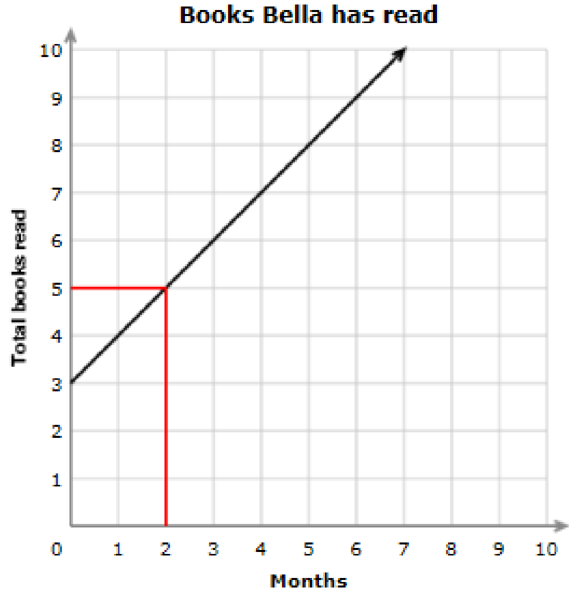
After belonging to the book club for 2 months, how many books will Bella have read in all?

books Submit

Figure 1 The assignment of the task

We will illustrate various types of providing of feedback in some digital learning systems. The learning system The planet of knowledge offers a modern learning environment for active acquisition of mathematical knowledge and skills. Interactive exercises in lessons often give students only minimal feedback about correctness of results. The response of the system consists of a graphic and audio alert. The lesson conclusion also includes a summary of the correctness of the exercise solutions. The interactive exercises available on www.math-tests.com provide not only minimal feedback about correctness of results but correct answer too. More extensive feedback is provided by the portal eu.ixl.com. For an example, we selected the word problem to interpret the graph of a linear function (see figure 1). In the event of an incorrect response, the system also provides the explanation of task solution (see figure 2).

Find 2 months on the *x*-axis. Move up until you intersect the graph.
Now move left until you intersect the *y*-axis.



You intersect the *y*-axis at 5 books. After belonging to the book club for 2 months, Bella will have read 5 books in all.

Figure 2 The explanation of the task solving

3 IDENTIFICATION AND ANALYSIS OF STUDENTS' ERRORS

During the planning learning process, the teacher considers the typical errors of students and looks for ways to detect these errors and to help students to master educational content. The teacher observes the work of students, questions them and analyses their answers. The teacher analyses the identified shortcomings and misconceptions and provides students appropriate examples as well as counterexamples supporting argumentation and developing critical thinking. Providing quick and effective feedback is a key factor in formative assessment. Students receive important information and guidelines from the teacher, where they made mistakes, how to correct their mistakes and how to improve their learning.

A major obstacle to acquisition and understanding curriculum is creation of deformed and faulty concepts, misunderstanding of basic contexts and methods of problem solving. These phenomena are the source of misconceptions and non-successes of students in problem solving. Another consequence is reflected in the reduction of interest in mathematics education. Therefore, it is important for the teacher to identify critical places in the learning content and to know the typical students' mistakes and misconceptions. In the paper, we focused on the selected basic parts of the elementary school mathematics: word problem focused on fractions and percentages and linear functions.

When students work with fractions, errors occur already in graphical representation of fractions. For fraction representations using circles or rectangles, students divide the whole by lines to unequal parts. Another problem is the identification of the whole by solving word problems requiring the use of fractions. The analogical error can also occur when students solve similar types of tasks with percentages. Fuchs pointed out in the paper (Fuchs, 2015) that this type of error often occurs in mathematics teaching at high school. The upper secondary school examination in mathematics in Czech Republic contain the task: 800 people came to the concert, which was a quarter of people more than the organizers expected. Determine how many people the organizers expected. Only 33.4 % of students solved this task correctly. In our research we gave to students in the first class at high school the analogical task adapted to the school environment in which number of people 800 was replaced with number of students 80 (see figure 3). The most common students' mistake is that one quarter does not count from the original whole but from the larger number and then subtract it from this number. Figure 3 shows the typical students' wrong solution.

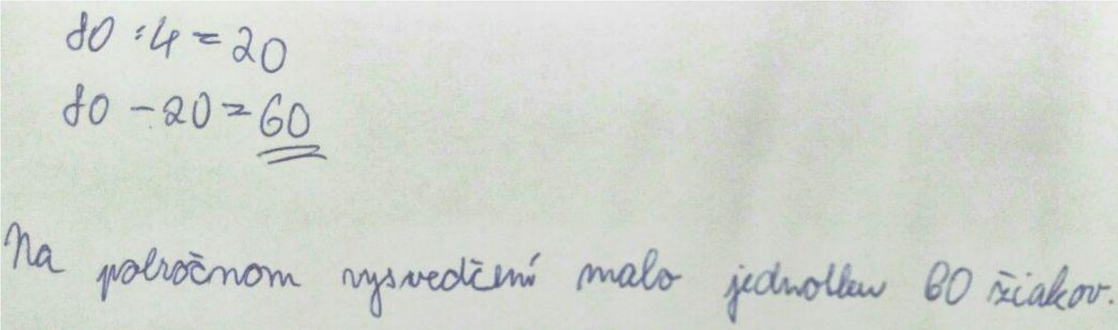


Figure 3 The most common students' wrong solution

When students investigate relationships between two variables they often analyse values written in tables. They can't characterize speed of changes of variable values and determine the type of dependence between variables. They prefer linear dependence without justification. Graphical representations are useful tool for better understanding and characterizing the type of dependence between variables. Diagrams in which the values of two variables are displayed next to each other can help students understand the graphs of functions built in the coordinate system. We have tried to take these aspects into account when creating an interactive application for the use of linear dependence to express the temperature in two scales (see figure 5).

4 EXAMPLES OF PROVIDING MINIMAL FEEDBACK IN MATHEMATICS LEARNING MATERIALS

The minimal feedback gives the student brief information about correctness or incorrectness of his/her answer. This simple feedback can also stimulate the student to think about each step of solution of the task or main idea which the student used for design a way how to solve the task. If the student get no feedback then he/she can make this mistake in the solving similar tasks. The absence of feedback becomes even more evident by doing homework. The minimal feedback may provide to the teacher in the learning process quick overview about students' success in their learning. Then the teacher can provide more effective help to students in need.

The minimal feedback may not only be based on a numerical value check, but it may also include a more complex evaluation of student's work results. The program Geogebra offers opportunities to control the visibility of objects that can also be used to provide feedback (Hohenwarter & Preiner, 2007). As an example, we selected the checking of correctness of a triangle construction which the student have to create in the program Geogebra. Assignment of the task: *Construct triangle ABC when given* $a = 5$ *cm*, $v_a = 6$ *cm*, $v_b = 4$ *cm.*

Construction of triangle *ABC* is displayed in figure 4. Figure 4 also contains auxiliary shapes which were used in the construction of triangle *ABC* and information for the student about correctness of the construction.

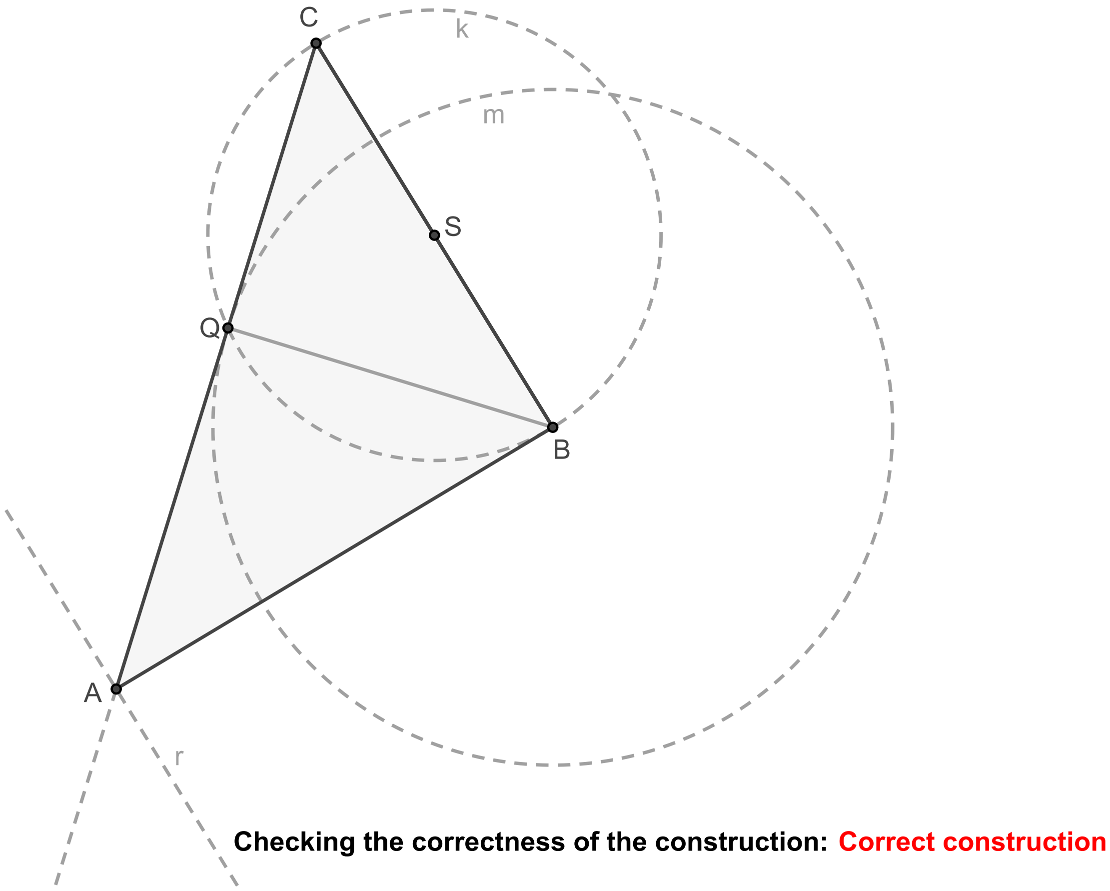


Figure 4 The construction of triangle *ABC* with minimal feedback

The segment *BQ* is the altitude to the side *b*. The construction of triangle *ABC* can start with constructing the altitude *BQ*. Another way of the construction of triangle *ABC* can be based on the construction of the triangle *QBC* using Thales' circle. The divergence of the solution process makes even more complicated the providing of feedback to errors in way of solving the task. Our design for providing the minimal feedback is only focused on checking of correctness of the resulting construction. If the corresponding elements in constructed triangle *ABC* are of the required sizes, then we can assume that the task is solved correctly. The student will not know in the case of negative outcome of feedback where he/she has made a mistake in the solution process, but he/she will know that it is necessary to edit the procedure for solving the problem or to ask for help. As a negative aspect of this design of feedback, we see the fact that a case might appear that the student would use the correct procedure to solve a task but he/she built some shape in the Geogebra environment incorrectly. Since triangle *ABC* does not have the required properties, so this solution will be considered incorrect. In the case of negative feedback, the teacher can provide a more accurate feedback to the students' solution process.

The second example is implemented in the program Geogebra. The interactive learning environment enables students to investigate linear dependence between quantities. Dynamic environment 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. Visualization using the built-in diagram (see figure 5) allows the student to easily determine the corresponding values of the variables and better understand the assignment of values of the dependent variable to values of the independent variable. Diagrams of this type are a suitable propaedeutic to understand function graphs constructed in coordinate system. 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.

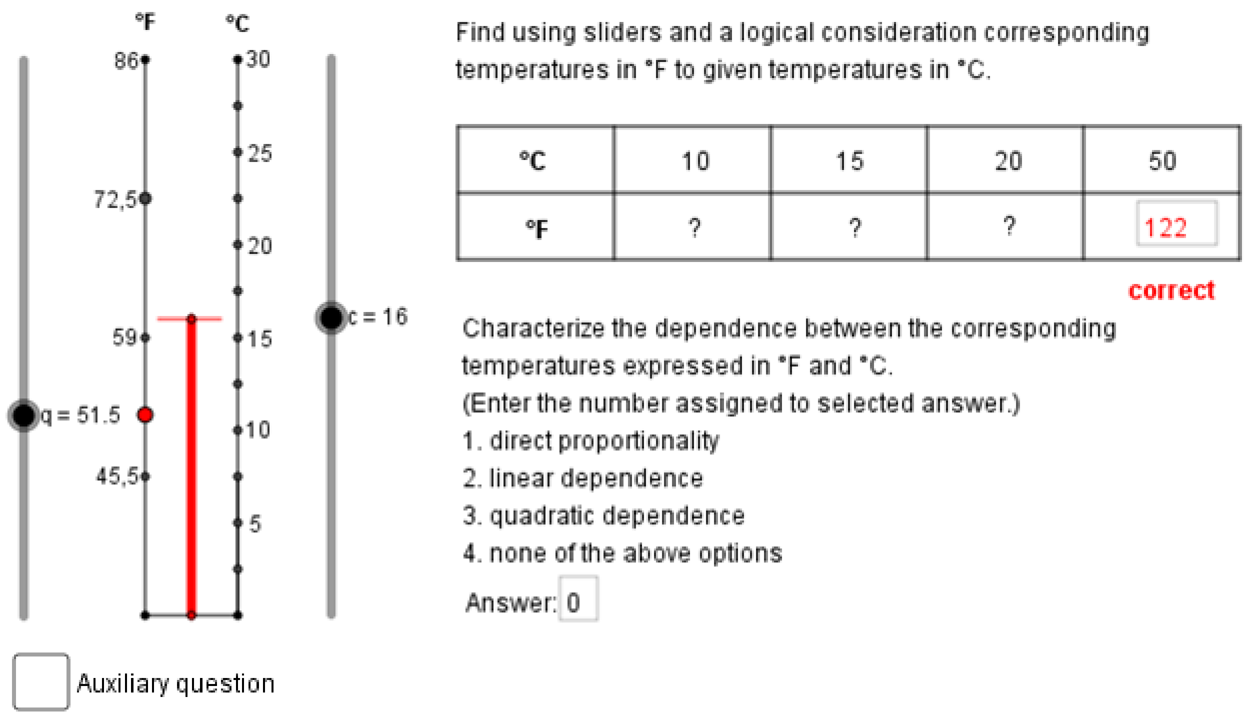


Figure 5 Mathematics learning environment for investigation of the functional dependence

The learning environment provides minimal feedback for written results. If a 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.

5 IMPLEMENTATION OF MORE EFFECTIVE FEEDBACK SUPPORTING FORMATIVE ASSESSMENT

When thinking about design and implementation of effective feedback supporting formative assessment it is suitable to focus on the critical parts of the 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 example is selected from teaching word problems focused on 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).

The example is implemented in spreadsheet environment. Tasks which are the main part of feedback are placed on individual sheets. Figure 6 illustrates the first task and control button Evaluation to call reaction of the system. The 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 this number from 80. If the student writes the incorrect result 60, he/she obtains the hint displayed in figure 6.

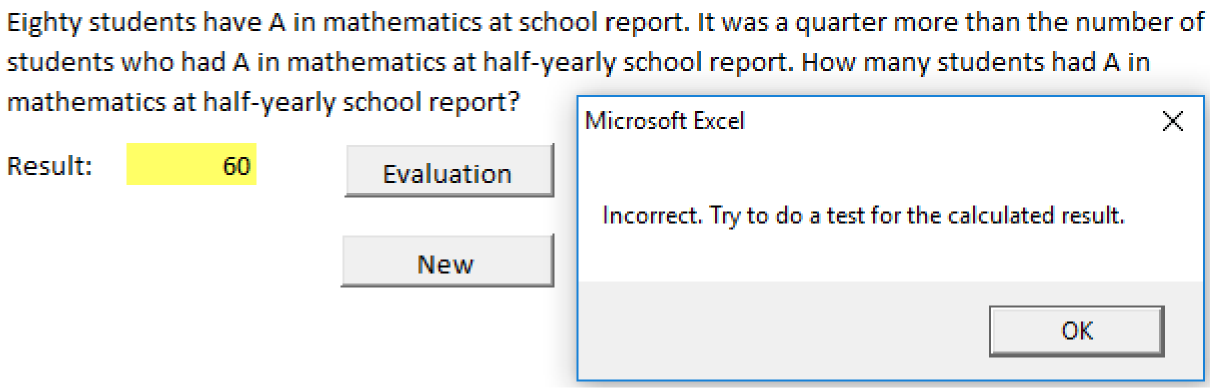


Figure 6 Part of worksheet with the first task

Writing the typical incorrect result 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 complete the equation: $x + x/4 = 80$. The student should realize a relation between the solution of the reformulated task and the solution of the original task. If the student solves the reformulated task correctly, he/she will get an additional task analogous to the first task: 300 students attended the school carnival. It was a third less than expected. How many students did they expect at the school carnival? 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: The price of the product after a 10% price increase was 242 €. What was the price of the product before the price increase? Feedback for incorrect results not related to typical error recommends the student to ask for help a teacher.

6 RESULTS AND DISCUSSION

Tasks from the described worksheet were used in the first class at high school (20 students). The average success of the students in the first task (see figure 6) 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. The correct students' solutions were based on the use of the formula $100 \cdot p/110$, where variable p represents price of the product after a 10% price increase. The analysis of the students' solutions shows that this knowledge has a formal character, because the students can not apply it in analogous situations when the percentages are replaced by fractions.

We designed feedback in the 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.

A better understanding of this type of word problem solving should be shown after assignment of the similar tasks after a longer period of time for the same students. In our next research, we are planning to investigate students' success in solving this type of word problems on a selected sample of high school students. The students will solve the tasks placed in an interactive worksheet with implemented feedback in the first stage of the experiment. In order to evaluate the solution process of tasks, the students will be asked to write the auxiliary calculations on the paper. The results of these students will be compared with the results of a test containing the same type of word problems that the same students will solve after a longer time period (at least 5 months). The first working hypothesis will include the statement that students will achieve greater success in solving tasks in the test than in solving tasks in the worksheet used in the first stage of the experiment. We will plan to use Mann–Whitney U test for statistical verification of the first hypothesis. For evaluation of results, the students who will do the typical error in solving the first task in the worksheet will be split into groups according to correctness of solution of the reformulated and additional task. The second working hypothesis will be aimed at the students who will do the typical error in solving the first task in the worksheet, but then they will solve the reformulated and additional task correctly. The second working hypothesis will include the statement that these students will achieve an average success at least 80% in the test containing the similar word problems. Another benefit of the experiment may be empirical findings obtained from a detailed qualitative analysis based on a comparison of students' solutions in the worksheet and in the test for different groups of students created according to their success in solving tasks in the worksheet.

CONCLUSION

Different types of feedback implemented in the mathematical digital learning materials were presented in the article. If the interactive learning activities are used directly in lessons in mathematics then teacher can provide feedback through appropriate arguments and auxiliary questions. Teachers have opportunities to analyse the variety of different students' ideas and strategies and use them to provide a bridge between their students' thinking and mathematical understanding. Teacher's learning experience allows him/her to provide students more advanced types of feedback focused on student's attention to his/her mistakes, and to direct his/her thought process to understanding of problem solving.

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 & Groen, 1993) demonstrate that initial student misconceptions are extremely difficult to correct using hints. Increasing feedback efficiency could ensure combining feedback with teacher help.

ACKNOWLEDGEMENTS

The article was created with support of the VEGA project no. 1/0265/17: Formative assessment in science, mathematics and informatics.

This article was created in the framework of the National project IT Academy – Education for the 21st Century, which is supported by the European Social Fund and the European Regional Development Fund in the framework of the Operational Programme Human Resources.

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ICTE Journal

2017, **6**(3): 36–39
DOI: 10.1515/ijicte-2017-0014

TREND ANALYSIS OF THE EDUCATIONAL CHOICE OF UNIVERSITY ENTRANTS AS TOOL TO IMPROVE THE QUALITY OF EDUCATIONAL SERVICE

Nadiya Mikhno[1], Liudmila Sorokina[2]

[1]Department of Sociology, Oles Honchar Dnipropetrovsk National University, Dnipro, Ukraine
krupskayanadiya@gmail.com

[2]Department of Sociology, Dniprovsk State Technical University, Kamianske, Ukraine
sludmila1906@gmail.com

ABSTRACT

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.

KEYWORDS

University teaching, sociological estimation, European standards and recommendations.

1 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).

2 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.

3 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, wheen 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.

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