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ICTE Journal Has a New Publisher

Dear readers,

Up until now, the ICTE Journal had no publisher and was being self-published by the Department of Information and Communication Technologies. Therefore, it was not available to the professional community. However, all of the previous and upcoming issues will now be published by De Gruyter, an independent academic publishing house founded more than 260 years ago which currently publishes over 1,300 new titles a year in various scientific fields and more than 700 open access journals. The editorial staff hopes it will help the ICTE Journal reach more readers not only in the Czech Republic, but also in Europe and all over the world. We also believe that as a result, the journal will be quoted more often, making you more interested in publishing your papers in it. Another significant improvement is the use of Digital Object Identifier (DOI). As all of your papers will be so identified, it will be easier to find the papers published in the ICTE Journal. Moreover, our readers can look forward to further changes which will go hand in hand with the improving standard of our journal.

Mobile technologies and social networks are used more and more often. The paper Mobile Devices and Social Networks within Pre-service Teacher Preparation by Jana Burgerová and Martina Adamkovičová presents the results of a research aimed at the ownership and use of mobile devices and social networks in the preparation of future teachers at the Faculty of Education of the University of Prešov. The results of this research can be used in updating the Moodle Learning Management System and other tools used in this or other departments. Moreover, they can also be used in updating various courses taught in education departments to cover the needs of future teachers who will most likely use the new devices and technologies in their teaching.

The paper Solving a Linear Optimization Word Problems by Using GeoGebra by Pavol Molnár presents the possibilities of the use of the GeoGebra application in mathematics instruction, particularly for graphical solution of linear inequalities. This paper also presents the results of experimental verification of the effectiveness of the use of this tool in a grammar school.

The so-called hybrid learning is one of the current ICT-supported methods. Aimed at this approach to learning, the paper Flexible Hybrid Learning: Comparison of Two Approaches and Learning Results introduces two models which have been used in teaching practice. Since hybrid learning has great potential, it needs to be further researched.

Aimed at the inquiry-based instruction, the paper Inquiry Based Education of Selected Informatics Topics – Analysis and Results presents partial results of the qualitative research on informatics instruction.

We hope that the abovementioned papers will inspire you and provide you with new information. Have a good read.

Tomáš Javorčík
Executive Editor

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MOBILE DEVICES AND SOCIAL NETWORKS WITHIN PRE-SERVICE TEACHER PREPARATION

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Abstract

The article provides results of monitoring the ownership and exploitation of mobile devices and social networks within the pre-service teacher preparation at the Faculty of Education, University of Presov in Presov, Slovak Republic. The research sample consisted of 473 respondents by the method of questionnaire. The tool was available online and included 12 items requiring both open and multiple choice answers of one, four or more choices. The data were processed by the IBM SPSS statistics software. The results are displayed in the form of figures and described. They proved students were equipped with various types of both the latest and other devices. They exploit them to access to study materials, information reflecting their personal and professional interests. Within the research the use of social networks was also under the focus. The results showed three types of social networks (Facebook, LinkedIn and Google+) are the most frequently accessed, both for university and further education.

Keywords

mobile device, mobile learning, mobile-assisted learning, m-learning, social network, higher education.

Introduction

The 21st century, also called the Information Age, has been the era of fast development of digital technologies. Currently, the generation of digital natives (i.e. those born 1980-2000) has enrolled at universities. They are strongly influenced by these technologies, growing up in the networked world, sharing global culture, and having computer skills and knowledge (Palfrey a Gasser, 2008, Morgan and Bullen, 2011).
Despite the term of digital natives was rather frequently exploited, currently this one has been replaced by the expression digital learners, as it reflects the 21st century student´s vision to a wider extent. The definition of a digital native differs from the view of the whole society, region, country, time period etc. At the same time, other criteria should be considered so as the core of the digital technology use by students could be clearly understood (Gallardo-Echenique, 2015).

The criteria, among others, also include the ownership and exploitation of mobile devices, particularly smartphones and tablets, which might prepare conditions for mobile-assisted learning. Advanced mobile devices such as “smart” cellular telephones are very popular primarily because they are wireless and portable. These functionalities enable users to communicate while on the move (Hussejn and Cronje, 2010). In spite of the fact, the current generation shows more willingness and ability to exploit technologies for educational purposes, the analyses in publications deadling with this topic are not in accord with the reality, Bennett, Maton and Kervin state (2008).
Reflecting the above mentioned, the main objective of this article is to find out how the pre-service teachers from the Faculty of Education, University of Presov in Presov, Slovak Republic, are equipped with mobile and other devices, so as the process of mobile-assisted learning could be started.

Theoretical background

Mobile learning (m-learning) and its exploitation in education has become an area of interest of numerous authors. Most of them observe mobile learning as a naturally evolved form of e-learning. However, this opinion has some deficiencies. E-learning occurred as a new form within the distance learning and its terminology is close to those applied in traditional learning. Although the applications of mobile learning are seen as an evolution of e-learning, m-learning is a characterized as technology and has its own terminology (Korucu and Alkan, 2011).
Keegan (2002) defines mobile learning as running of education through PDAs, pocket PCs and mobile phones. However, he recognized that mobile learning should focus on the actual mobility of the device. Mobile learning should be “restricted to learning on devices which a lady can carry in her handbag or a gentleman can carry in his pocket” (Keegan, 2005, p. 33).
Hussejn and Cronje (2010) state, mobile learning as an educational activity makes sense only if the technology in use is fully mobile and if the users of the technology are also mobile while they learn. These observations emphasise the mobility of learning and the significance of the term “mobile learning”. Traxler (2007) and other supporters of mobile learning define mobile it as public, used by a learner as he or she participates in higher education. Others define and conceptualise mobile learning by placing a strong emphasis on the mobility of learners, the mobility of learning, and the experience of learners as they learn by means of mobile devices. Two terms should be explained in detail, when mpbile learning is under the focus: the mobility and the learning. On the one hand the “mobility” refers to the capabilities of the technology within the physical contexts and activities of the students as they participate in higher learning institutions. On the other hand, it refers to activities of the learning process, the behaviour of the learners as they use the technology to learn. It also refers to the attitudes of students who are themselves highly mobile as they use mobile technology for learning purposes. Traxler (2007) notes that there are some definitions and understandings of mobile education, which focus only on the technologies and hardware, whether it is a handheld and mobile device such as personal digital assistants (PDAs), smartphones or other wireless devices. These definitions undermine a proper understanding of the uses of mobile technology in learning by confining their explanations and descriptions to the actual physical way in which the technology operates. Other definitions place more emphasis on what learners experience is, when they use mobile technologies in education, while others inquire how mobile learning can be used to make a unique contribution to the advancement of education and other forms of e-learning. In the context of higher education Hussein a Cronje (2010) emphasize that using the mobile device as a signifier, the concepts of mobility can be divided

into three significant areas: *mobility of technology, mobility of learner and mobility of learning.*
Results of the researches conducted at three American universities applying focus groups of students resulted in the fact that mobile learning offers much more educational potential than simply accessing resources. (Grant and Gikas, 2013). It is important to note that even though mobile learning may look like web-based learning in that mobile computing devices connect different technologies to exchange information, the mobile device is "a contemporary paradigm for connecting, communicating and getting things done on mass-customized and yet personal relationship level that extends to the devices themselves" (Kainz 2011, p. 12).
In the Czech and Slovak Republics partial researches have been conducted in the field of the exploitation of mobile devices within education, e.g. Šponiar and Brestenská, 2014; Kajanová and Šedivá, 2012; Šimonová and Poulová, 2015; Maněnová, 2013), which support the hardware readiness for the mobile learning implementation into education.

Participation the Faculty of Education, Presov University, in the exploitation of mobile devices within primary education

Since 2013 the exploitation of tablets for educational purposes has been closely connected to the Slovak project School on the Touch. Primarily it focused on providing 400 tablets Samsung Galaxy Note 10.1. to 15 selected Slovak schools. The touch screen could be accessed through the tablets via Samsung School application. Instead of other activities, the equipment enabled to start the project My First School. The Faculty of Education, University of Presov, was one of the project supporters – the only one dealing with pre-service teacher preparation in the Slovak Republic on the pre-primary and primary level and supported them in preparing activities and materials towards implementation of digital technologies on this level of education. The Faculty of Education, University of Presov, participated in the learning content preparation and reviewer of digital education methodologies.
Reflecting this state, students of study programmes Pre-primary and Primary Education at the Faculty of Education, University of Presov, can acquire the newly created field didactics, as well as with the use of tablets and other mobile devices. Therefore, were conducted the below described research, particularly focusing on students´hardware equipment and the exploitation for educational purposess.

Methodology of Research

The research was structured into … phases: (1) research sample was defined, (2) the research tool was created and piloted, (3) the collected data were processed by statistics software, displayed in the form of figures and described.

Research sample

Totally, 473 respondents were included in the research sample having following characteristics:

- 460 female and 13 male respondents;
- 376 of them between 20-24 years old, 65 below 20, 14 between 25-29 years, 6 belonged to 30-34 year group, ř between 35-39 years and 7 respondents were 40+ years old;
- 448 of them were enrolled in the full-time form of study programmes, 25 respondents attended part-time forms;

- on the bachelor (410), master (62) or doctoral (1) levels;
- 454 of them studying any of teaching study programmes – for the pre-primary and primary level (192), for handicapped learners (78).

Research tool

The method of questionnaire was applied in the research. The questionnaire included 12 items (questions), eight dealing with mobile devices and their exploitation (group 1), four focused on preferred social networks (group 2):

- Mobile devices exploited for communication with family, friends (four choices)
- Mobile devices exploited for communication at school, at work (four choices)
- Mobile devices exploited for entertainment (all choices)
- Mobile devices as sources of information for university study (all choices)
- Mobile devices exploited for university study (all choices)
- Mobile devices as sources of information for further education – interests, profession (all choices)
- Mobile devices exploited for further education – interests, profession (all choices)
- Mobile devices owned by respondents
- Preferred social network: Facebook
- Preferred social network: LinkedIn
- Preferred social network: Google+

Respondents provided answers in the open format or multiple choice format of one or more choices. The link to the questionnaire was available to the students above listed study programmes. The return rate 86 per cent.

Research results

The collected data were processed by the IBM SPSS statistics software, displayed in the form of 12 figures and described.

When comparing figures 1 and 2 where mobile devices exploited for communication with family and friends (figure 1), and at school and work (figure 2) are displayed, it can be stated the results are rather similar. The most surprising finding is that even living in the times of e-society, the personal contact is still the most frequent way of communication, both in the private and professional field. Then, the use of notebooks and mobile phones follows, however, been more frequent for communication in the private sector, which is surprising. The use of other devices is nearly identical in both areas.

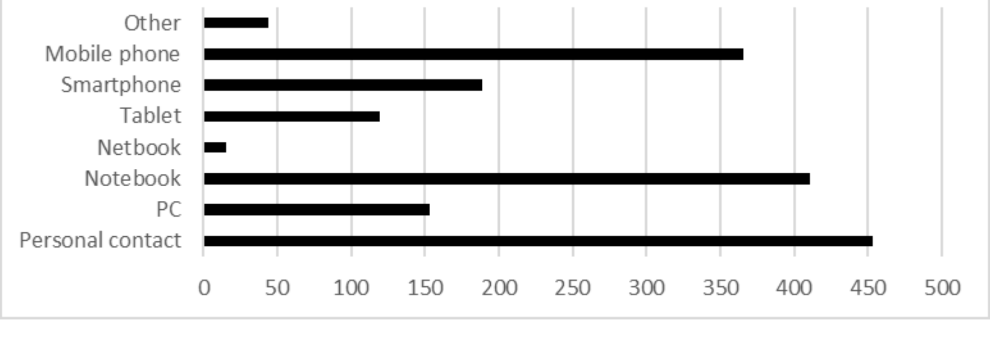

Fig. 1: Mobile devices exploited for communication with family, friends

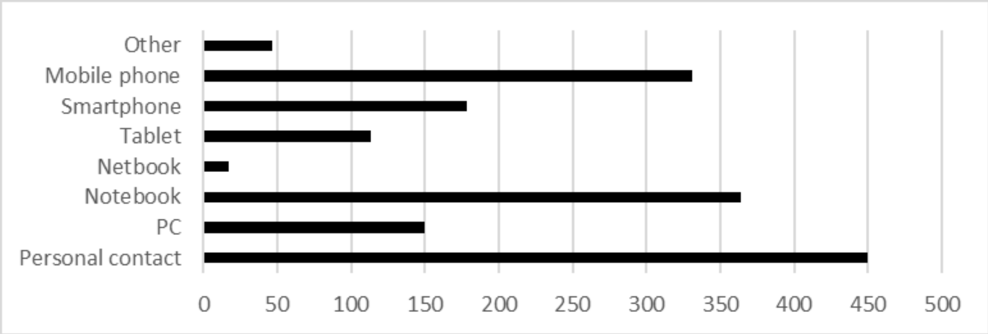

Fig. 2: Mobile devices exploited for communication at school, at work

Different state was discovered in the field of entertainment. Notebooks were "the winner" in this field, closely followed by TV. The TV is definitely not a mobile device according to the latest definitions; however, it was included from the reason young people often proclaim they do not watch TV because of the low quality programme from their point of view. These data prove it is not fully true (figure 3).

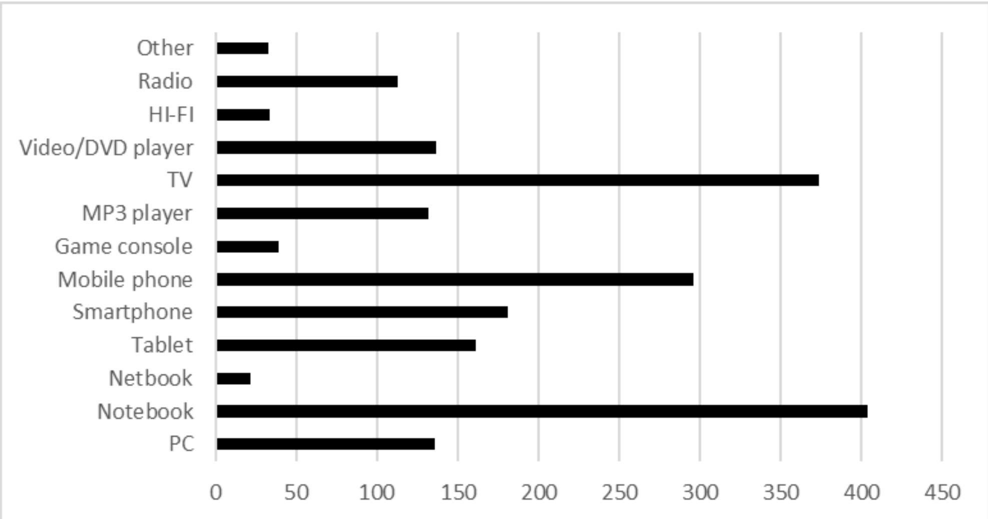

Fig. 3: Mobile devices exploited for entertainment

Following two figures deal with university study: mobile devices exploited as sources through which students have the information and study materials available are displayed in figure 4, whereas those used directly for the process of learning are in figure 5. The data show that among sources of information for univeristy study students strongly prefer personal attendance of lectures. This approach is supported by online subjects in the form of courses in the LMS Moodle and other materials which are available from the Internet free of charge. For the university study, i.e. for the learning process, student mostly exploit notebooks and mobile phones.

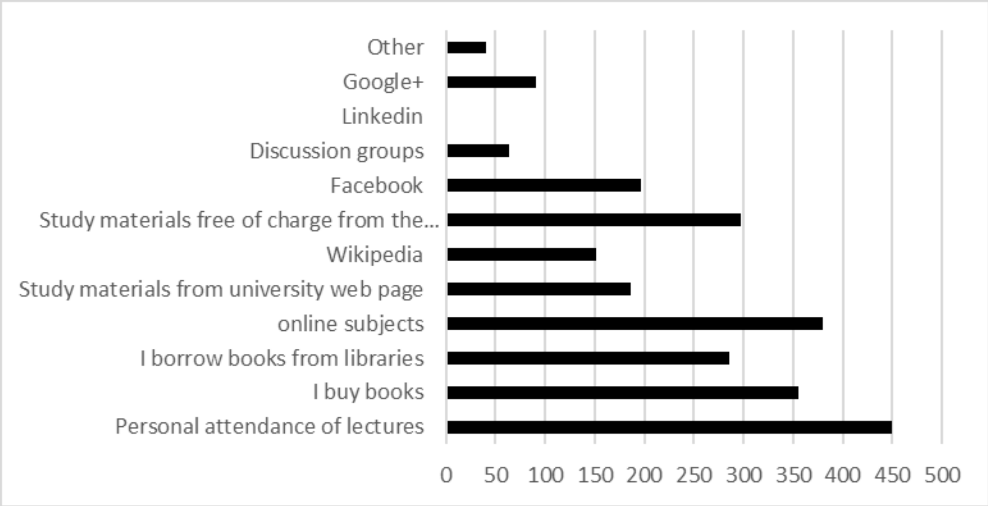

Fig. 4: Mobile devices exploited as sources of information for university study

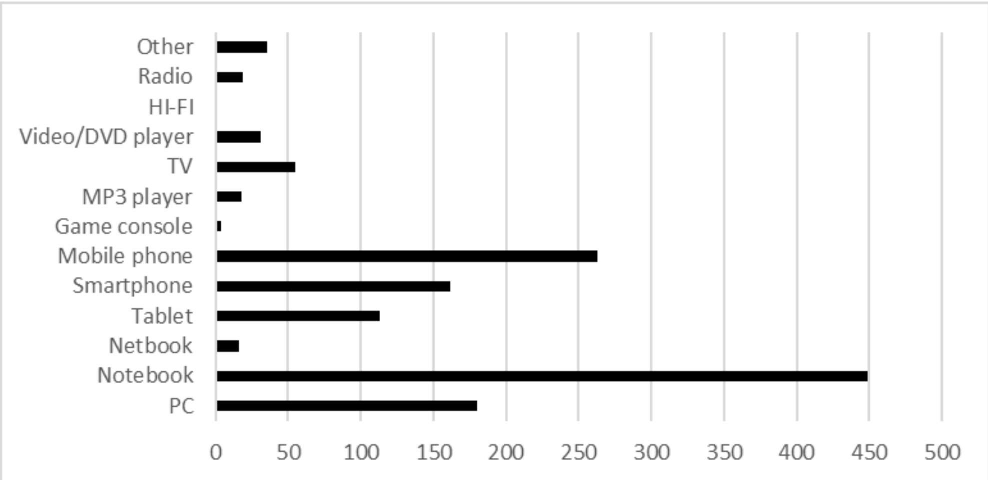

Fig. 5: Mobile devices exploited for university study

The results are nearly identical in the field of further education. Within this area, respondents interest- and profession-related exploitation of mobile devices were monitored. As displayed in figure 6, study materials available free of charge from the Internet are most frequently exploited. However, personal attendance of lectures reflecting respondents´ interests and/or professions are also frequently used, as well as books from libraries, buying new books, or downloading materials and discussions from Facebook. Most frequently used mobile devices for this purpose are notebooks, mobile phones, computers and smartphones, and TV was also often mentioned (figure 7).

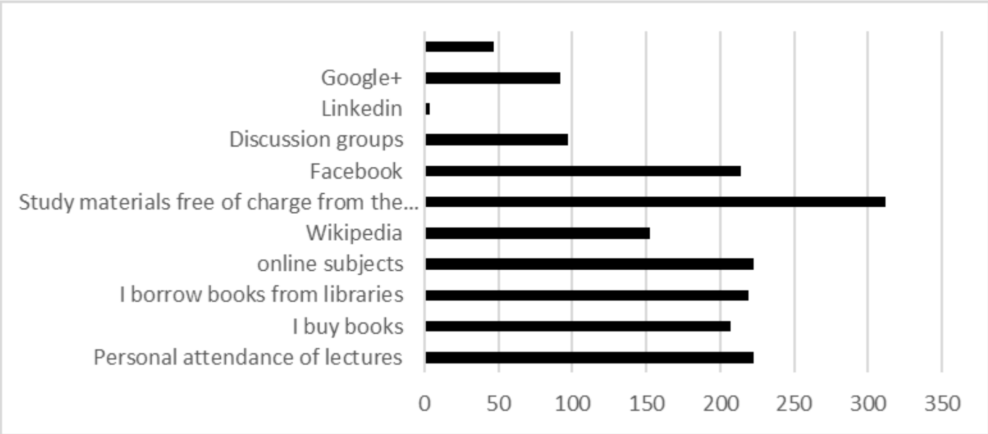

Fig. 6: Mobile devices as sources of information for further education – interests, profession

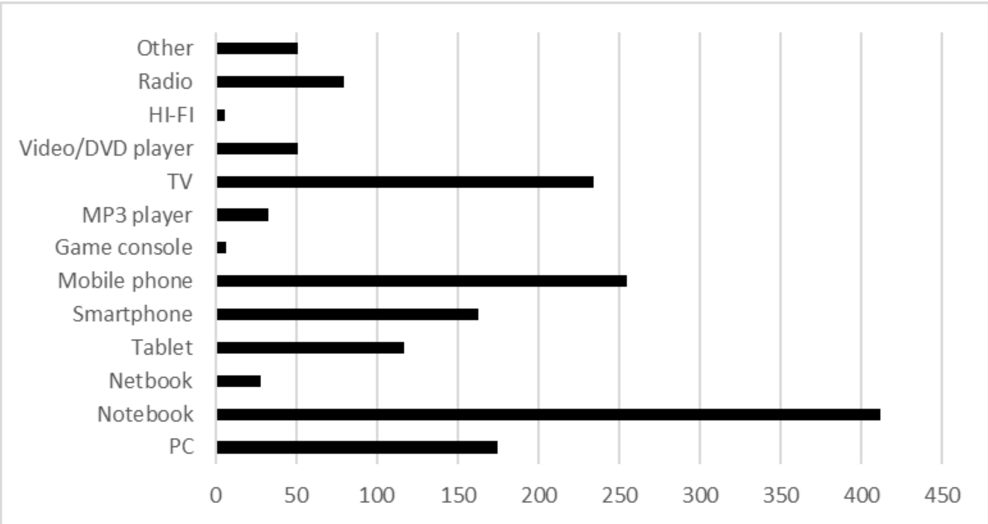

Fig. 7: Mobile devices exploited for further education – interests, profession

Within the final question of the group 1 dealt with the ownership of mobile devices. In other words, the question was, what mobile device/s respondents possess so as they can use them for both the private and professional/educational purposes. Figure 8 displays that notebooks were possessed by most repondents, followed by mobile phones, computers, tablets and smartphones. Reflecting the total amount of devices, this result shows there is high probability each respondent owns at least one type of device. This result means, the implementation of mobile devices into education at the Faculty of Education, University of Presov, can be started/run.

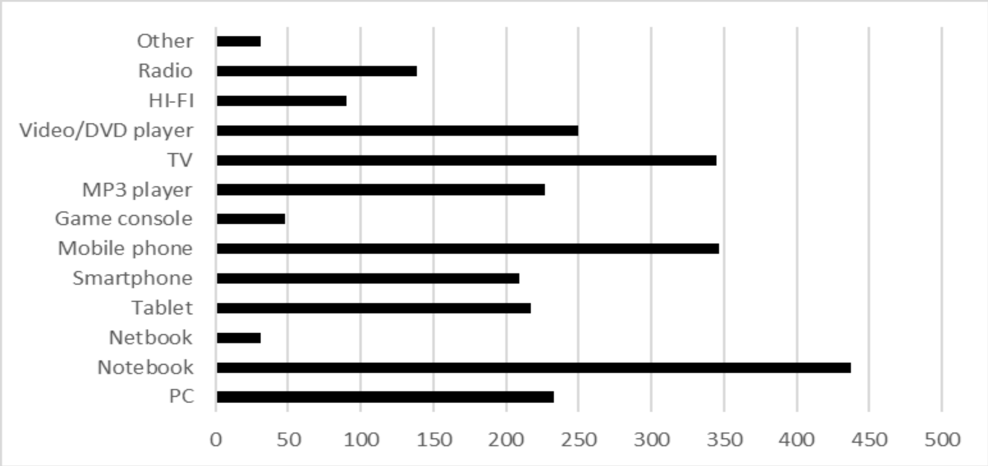

Fig. 8: Mobile devices students own

Following four questions dealt with social networks. Three of them were strongly preferred: Facebook (figure 9), LinkedIn (figure 10) and Google+ (figure 11). Figure 12 focuses on the use of other networks – among them, not a single one was listed as more than exceptionally used. As expected, Facebook was the most frequently used social network by nearly 90 % of users. No, or only exceptional use was detected with LinkedIn, and Google+ showed a partial exploitation, with only 3 % of those who use it several times per day.

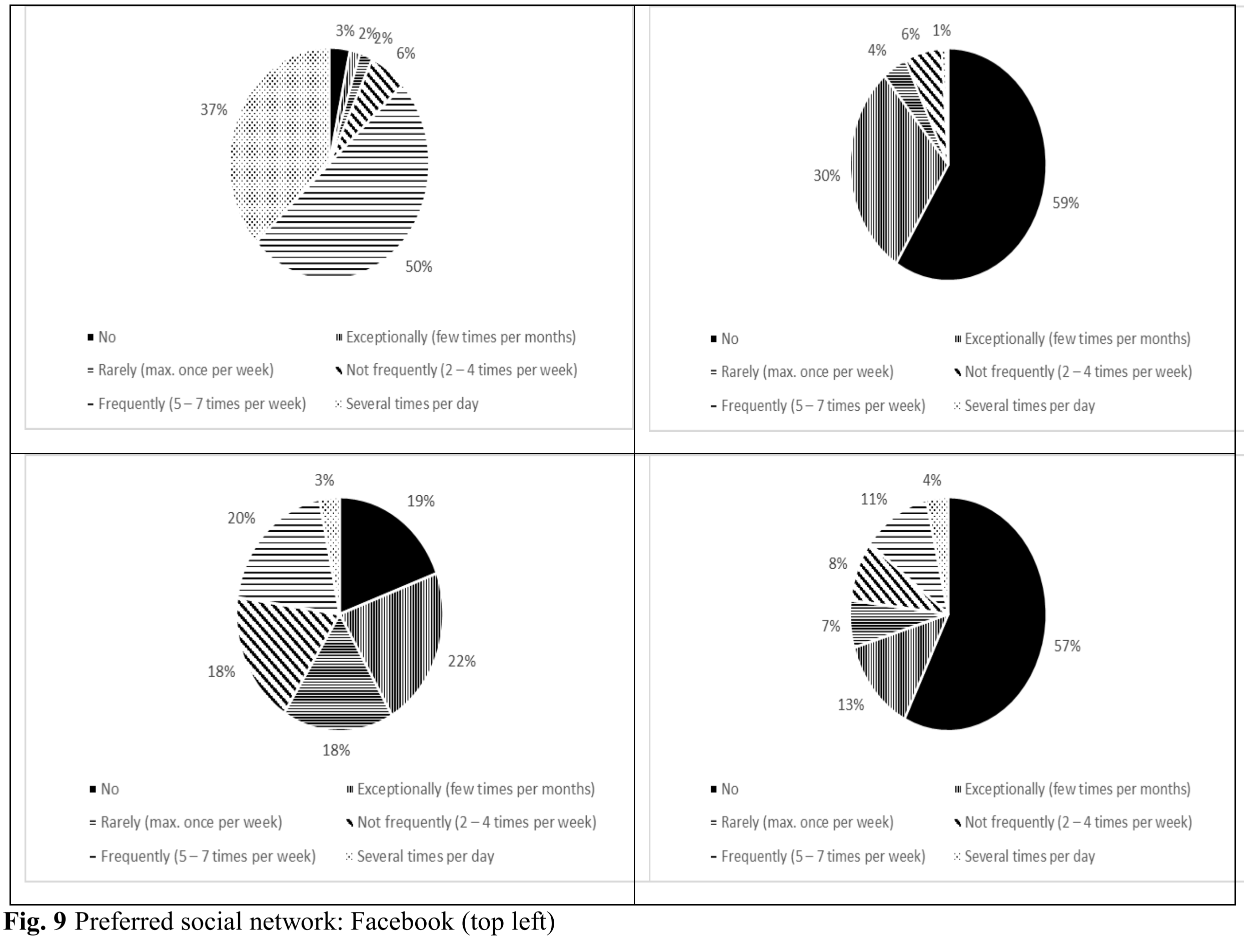

Fig. 9 Preferred social network: Facebook (top left)
Fig. 10: Preferred social network: LinkedIn (top right)
Fig. 11: Preferred social network: Google+ (bottom left)
Fig. 12: Other social networks exploited by respondents (bottom right)

Conclusion

Faculty of Education, University of Presov, Slovak Republic, has an ambition to stay a leader in pre-service teacher preparation on the pre-primary, primary level and pedagogy of learners handicapped in various fields of education. This task is closely related to reflecting latest trends into this process – and mobile devices and technologies belong to them without any hesitation. In correlation to the above presented results, the future attention should be paid mainly to:

- ✓ providing efforts to the infrastructure management and administration of mobile devices in classrooms and laboratories of the Faculty of Education,
- ✓ providing sufficient equipment (both hardware and software) to the pre-service teachers.

Reflecting the results of research on the exploitation of the Learning Management System Moodle and its tools conducted several years ago, students expected academic staff would be initiative, active and professional even in the field of mobile devices implementation into education (Adamkovičová a Burgerová, 2014). It means:

- ✓ the professional training of teachers of general and subject didactics will be requiredin the field of mobile devices implementation,
- ✓ tools (economic, motivation) to support teachers exploiting the mobile devices and technologies will help the process.

Last but not least, the learning contents of the above mentioned subjects, particularly ICT Didactics for primary level teachers, will have to be adjusted to the new requirements on graduates, including cloud platforms, applications and social networks in education, and the legal protection of the learning contents in mobile learning.

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SOLVING A LINEAR OPTIMIZATION WORD PROBLEMS BY USING GEOGEBRA

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Abstract

Today's modern age is characterized by the rapid development of information and communication technologies, which is also reflected in the educational process. It is therefore necessary to prepare the young generation of even at primary and secondary schools to solve problems from real life. Using the appropriate motivation, innovative methods and application of modern information and communication technologies into the teaching process, we can succeed. Constructions created using by dynamic geometry systems bring new opportunities to learning. The aim of this article is to introduce the possibility of using GeoGebra in graphics solution of system of linear inequalities and also in the geometric interpretation of solutions to word problems leading to the linear optimization. The article describes the observations of experimental teaching, where was used GeoGebra. The experimental teaching was conducted at a grammar school in Košice. GeoGebra offers suitable tools to create graphical models in solving the optimization problems.

Keywords

GeoGebra, mathematics teaching, modelling, linear optimization, system of inequalities

Introduction

Technology comes in many variants such as data handling and graphing software, computer algebra systems, programming languages, programmable calculators, and dynamic geometry systems (DGS). Among these, the use of DGS has gained popularity in recent years in parallel to the development of various products such as Cabri, Geometer's Sketchpad, and most recently GeoGebra. Kokol-Voljsc (2007) stated that in teaching and learning geometry, particularly Euclidean geometry, and solving problems related to geometry concepts, DGS are the most appropriate tools. Laborde (2002) pointed out that the use of DGS evolved over time from being a visual amplifier to a fundamental component that enhances conceptual understanding. Duval (1998) argued that DGS are superior to paper-and-pencil based (PPB) methods as they dissociate the "figure" from the "process of drawing". This allows students to understand the properties of the figure before it is being sketched on the screen.

In 2001, Markus Hohenwarter began to develop the system GeoGebra. Gradually, the group expanded by an additional programmers. The creators of GeoGebra continue its development and constantly replenished to new functions and modules. In an effort to create a complex mathematical program has been implemented into the GeoGebra a module for computer algebra systems (CAS). (Hohenwarter & Hohenwarter, 2013) The current version (version 5.0) now offers to users the window on the 3D geometry which allows you to work with the solids in three-dimensional coordinate system. GeoGebra is now functional on a mobile platform that allows its use for tablets, resp. for mobile phones.

Teaching fourteen and fifteen year old mathematics presents many challenges. Engaging these students can be difficult, especially as the mathematics they study becomes more abstract. Dynamic geometry offers opportunities to bring the real world into the mathematics classroom, to add visualization, colour and animation not possible in a traditional classroom and to deepen the mathematical thinking we expect of the students in various topics of the curriculum. (Pierce & Stacey, 2011)

There are too many surveys about the using DGS in mathematics education. Many of them show that DGS are not making sufficient and if they are used, so almost exclusively in teaching geometry. From surveys, it is clear that the GeoGebra is the most popular software, and therefore we continue to devote only about the GeoGebra (Molnár & Lukáč, 2015), (Kriek & Stols, 2011), (Ainley et al., 2010). So we decided to show the possibility of such the GeoGebra can also be used in other areas such as in geometry.

Graphical solution of system of linear inequalities

At the outset, we would like to show the possibilities of the program GeoGebra for graphical solution of system of linear inequalities (Task 1).

Task 1

Solve the system of linear inequalities graphically in R^2:

$$\begin{aligned} y - x &\geq 0, \\ y - 3x &\leq 0, \\ x &\leq 2. \end{aligned}$$

The solution of this system is by using GeoGebra very visual. Just write the three inequalities to the input line of the form:

$$(y - x \geq 0) \land (y - 3x \leq 0) \land (x \leq 2)\ .$$

GeoGebra then draws a set of possible solutions to inequalities of the system (Fig. 1). Then we can by using the tool "Point on object" to insert point that we can move within the drawn set. From an algebraic window we can read its coordinates and therefore also the solution of system of linear inequalities (Fig. 1).

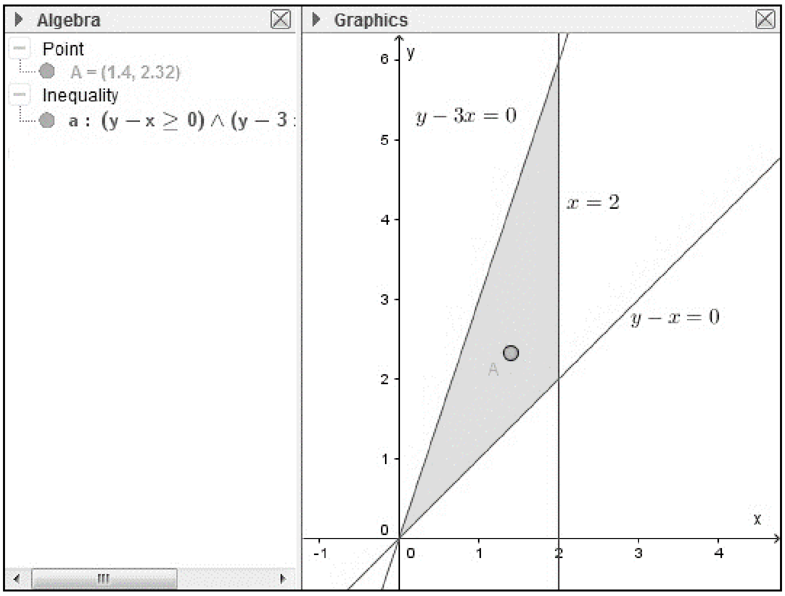

Fig. 1: Solution of system of linear inequalities

The experimental Teaching

Experimental teaching we realized at the grammar school in Košice. It consisted of two lessons. During the lesson, which preceded our experimental teaching students tackled a graphical solution of linear inequalities. They drew in their workbooks half-planes that meet the specified inequalities. During the experiment we tried to actively engage students into exploring the context. We also wanted to raise students' interest about the linear optimization. In the experiment was involved mathematical class in the first year. In the classroom was located during the experiment 25 students. Of which was 16 boys and 9 girls. Students during these two lessons were given two worksheets. During the first lesson students were familiar with the graphical solution of linear inequalities, the issue of linear optimization, as well as with the program GeoGebra. Students have mastered control of the GeoGebra very quickly, because it was for them intuitively. During the second lesson, students were working with second worksheet, which was devoted to word problems leading to the linear optimization. In the next part of this article we will focus on both worksheets.

The worksheet 1

Worksheet 1 consisted of six tasks. Tasks 2 – 4 formed a worksheet 1. Besides these, there were three more tasks, but out of curiosity we pick out just those three.

Task 2

Solve the system graphically:

$$\begin{aligned} x &\geq -2 \\ x - y &= 0 \\ y &\leq 2 \end{aligned}$$

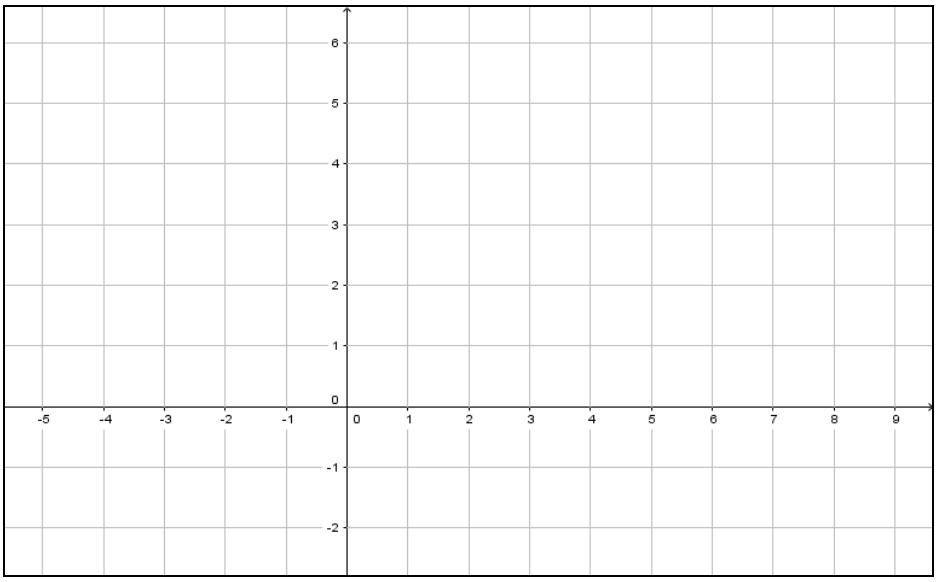

Fig. 2: Task 2 request

Note: Students have mastered that task quite well. Students had to solve a system of two inequalities and one equation. Twenty students had that task resolved correctly and five students had incorrectly solutions. For students who have not solved that task correctly was the biggest problem an unclear cross hatch (shown in the next task), or bad determine the half-plane under the sign of inequality (Fig. 3). It was clear to see that some students had problems with determining the correct half-plane that satisfies the inequality. Some students identify the right half-plane with the help of chance.

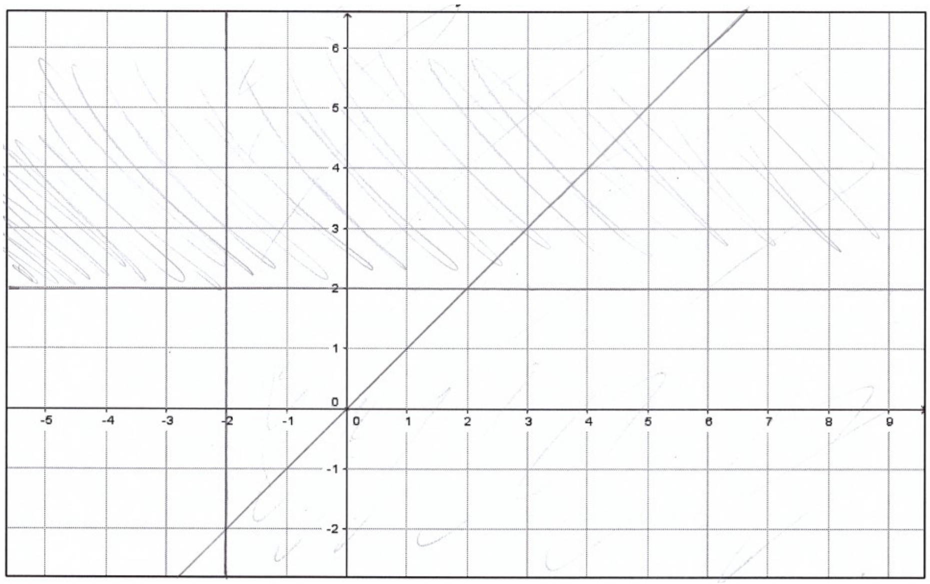

Fig. 3: Demonstration of the student solution of Task 2

Task 3

Solve the system graphically:

$$\begin{aligned} x + 2y &\leq 2 \\ 2x - y &\leq -1 \\ x + 3y &\geq 0 \\ 2x + y &\leq -3 \end{aligned}$$

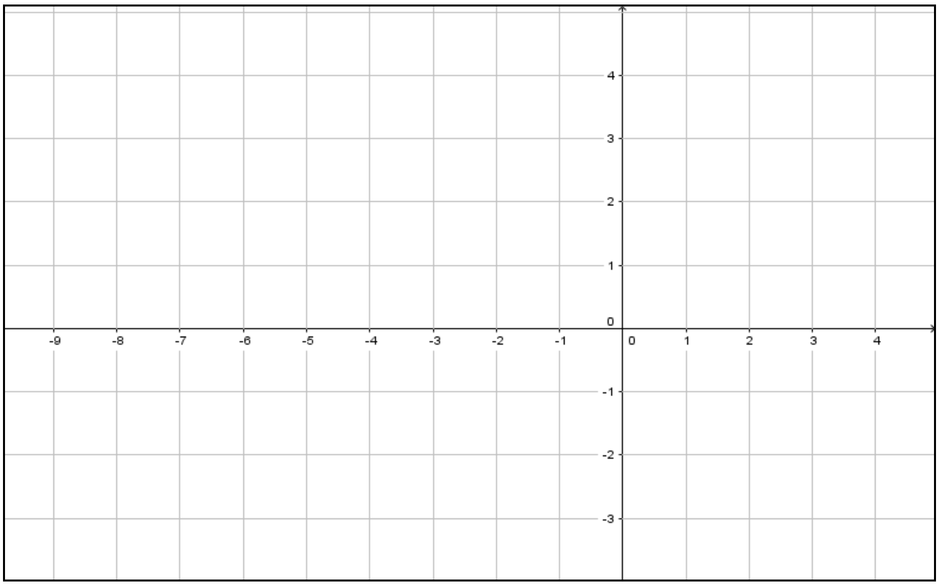

Fig. 4: Task 3 request

Note: In this task was reflected the confusing cross hatch even more than in the previous task (Fig. 5), as it is a system of four inequalities. That task correctly solved fifteen students. Other students solve this task wrong, respectively, the task did not manage to resolve. Some of the students who did not manage to resolve that task had no problems with previous tasks. Therefore, we conclude that did not solve task of the time pressure. At this task has been our intention to show to students the benefits of GeoGebra. Of course only after the submission of the worksheet.

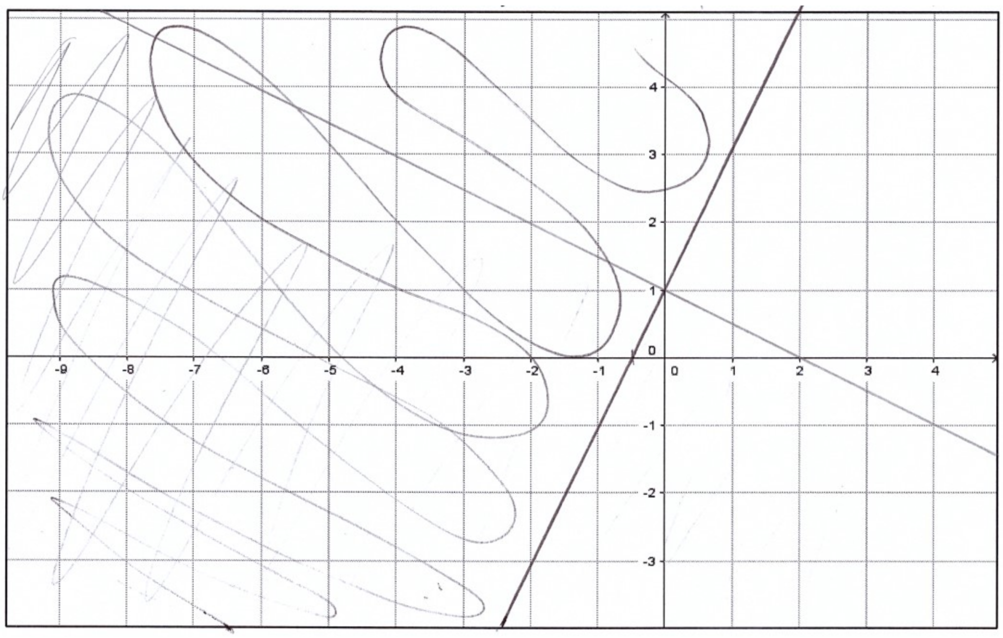

Fig. 5: The confusing cross hatch

Task 4

Locate such solution of the system of inequalities

$$y \geq 0$$
$$5x + y \geq 5$$
$$x + y \leq 5$$

for which is the number x + 2y

a) the least
b) the greatest.

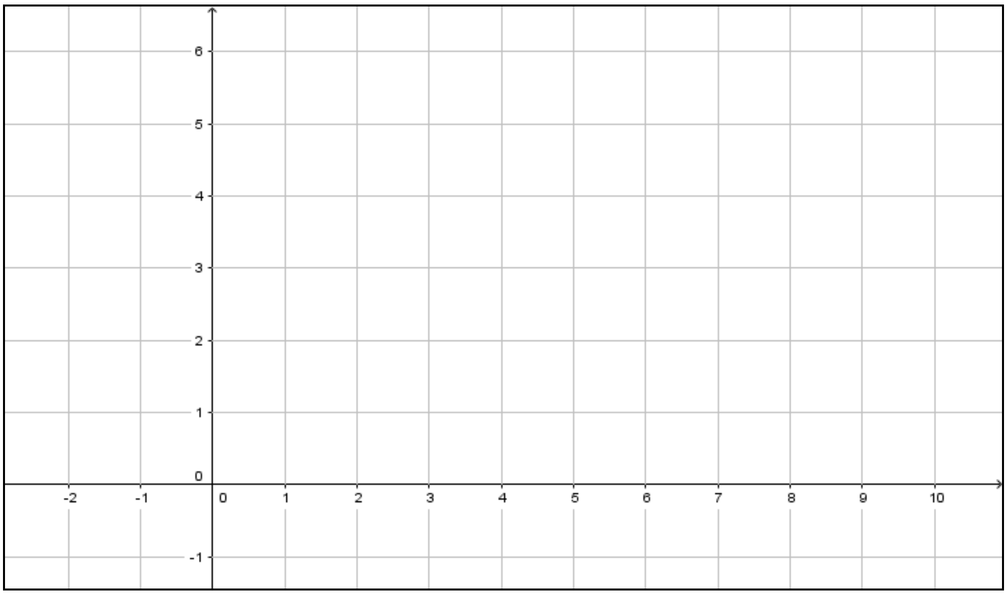

Fig. 6: Task 4 request

Note: This last task served as a transition from the solving systems of linear inequalities to the linear optimization. Since the some students have not manage even a previous task, so that it was even worse. Of course some students have managed to finalize the solution of the task (Fig. 7).

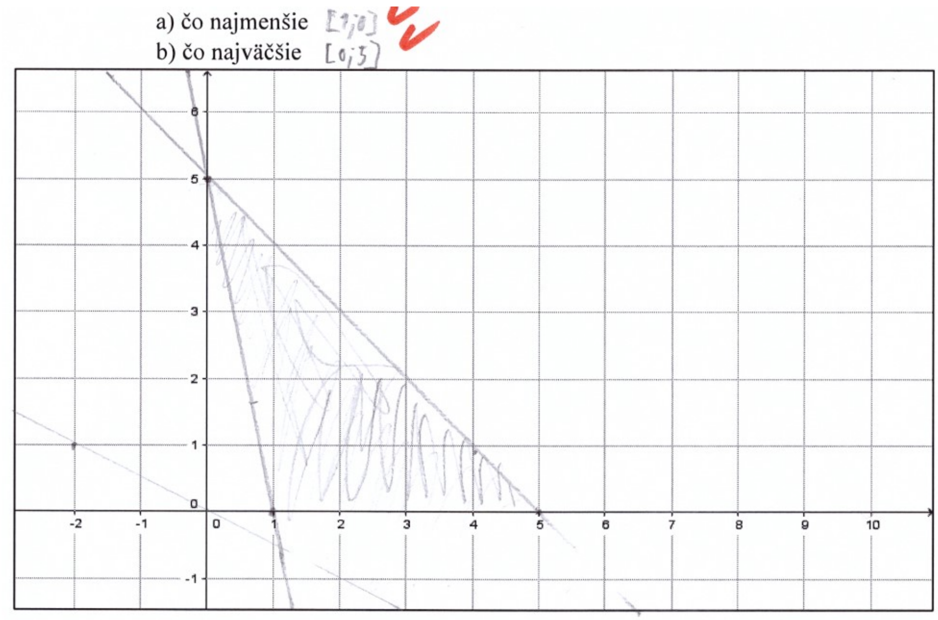

Fig. 7: Demonstration of the student solution of Task 4

After the handover of the worksheet we showed to students the possibility of the system GeoGebra. Students who did not manage to solve all tasks have been happy that they with the GeoGebra can do it. Later we returned worksheets to students so that they can solve the tasks at home by using GeoGebra.

In the next lesson we continue the last task from the first worksheet and we went through on word problems on linear optimization.

The worksheet 2

Worksheet 2 consisted of three tasks. Tasks 5 – 7 formed a worksheet 2. Students solved the worksheet individually during a one lesson.

Task 5 (Cechlárová)

FarLak company produces two kinds of paints: Z and V, which sells for 5000 (Z) and 2000 (V) EUR per tonne. The company uses two kinds of raw materials, A and B, whose stocks are 6 t (A) and 5 t (B). Per one tonne of paint Z are necessary 3 parts of raw materials A and 1 part of raw materials B. To produce one ton of paint V are necessary 2 parts of raw materials A and 2 parts of raw materials B. How many of the paint type, the company FarLak do, if they want to make the most money?

Note: Any data for which there is a star (*) have not been on the worksheet and students had to supplement their own.

Students have available in this task a summary table, under which they had to complete the condition (inequality) for raw material B.

	Paint Z	Paint V	Resources (t)
Raw material A	3/4	2/4	6
Raw material B	1/4	2/4	5
Price (EUR)	5000	2000	---------
Quantity (t)	x	y	---------

On the basis of the table, students have work towards the following system of linear inequalities:

The condition for the raw material A:

$$\frac{3}{4}x + \frac{2}{4}y \leq 6$$

Students had to complete the condition for the raw material B:

$$\frac{1}{4}x + \frac{2}{4}y \leq 5\ (*)$$

Amount of paint Z:

$$x \geq 0$$

Students had to complete the condition for paint V:

$$y \geq 0\ (*)$$

Students had written in this task also the prescription of the target function which is the revenue which we want to maximize:

$f(x, y) = 5000\text{x} + 2000\text{y} \ \rightarrow \text{maximize}$

and also a shape the enrolment of inequalities in which they should be entered in the input line in GeoGebra:

$(3/4x + 2/4y \leq 6) \wedge (1/4x + 2/4y \leq 5) \wedge (x \geq 0) \wedge (y \geq 0).$

Students had into the figure (Fig. 8) draw a line that will provide a maximum revenue.

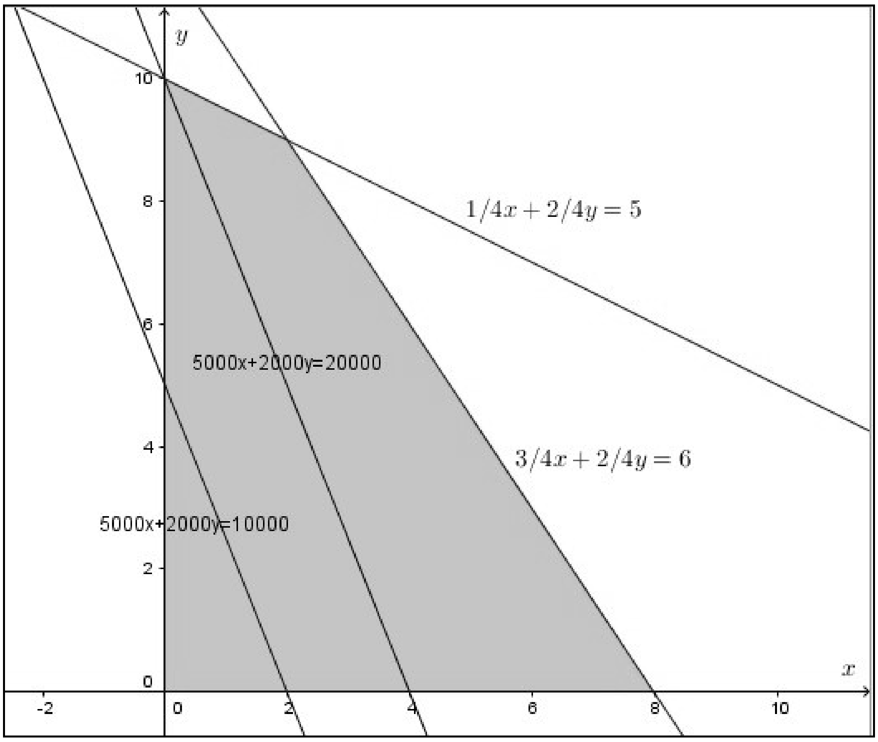

Fig. 8: Producing paints

Finally, students should formulate an answer and thus, if the company FarLak wants to make the most, then it must produce 8 tons of Paint Z and 0 ton of Paint V. The revenue in this case would be 40 000 EUR.

Note: All of 25 students knew the correct plot a straight line representing a maximum direct revenue, which proves that they understand the issue of optimization. Up to 11 of them been not written an answer. 7 wrote a full answer and 7 wrote a result in the form x = ... y = ... For all students it was clear that they understand the issues of linear optimization.

Task 6 (Oravcová, 2013)

Research about the development of animal production showed that the fattening of farm animals is very advantageous if in the daily doses of each animal will receive at least 6 units of nutrient A, at least 12 units of nutrient B and at least 4 units of nutrient C. For fattening using two types of feed, K_1 and K_2. One kilogram of the feed K_1 contains 2 units of the nutrient A, 2 units of the nutrient B and no nutrient C unit. One kilogram of the feed K_2 contains 1 unit of the nutrient A, 4 units of the nutrient B and 4 units of the nutrient C. Furthermore, we know that for 1 kg of the feed K_1 to be paid 0.50 EUR and of the feed K_2 to be paid 0.60 EUR per 1 kg. How much kilograms of the feed K_1 and K_2 should be given to one animal, the cost of fattening were minimal?

Note: Any data for which there is a star (*) have not been on the worksheet and students had to supplement their own.

Also in this task students have at their disposal a table, but some details should add themselves on the basis of definition of the task

	Feed K_1	Feed K_2	Minimum quantity
Nutrient A	2 (*)	1	6
Nutrient B	2 (*)	4 (*)	12 (*)

Nutrient C	0	4 (*)	4 (*)
Price (EUR)	0,50 (*)	0,60 (*)	-----------
Quantity (kg)	x	y	-----------

On the basis of the table, students should ultimately to bring about the following system of inequalities:

Nutrient A: $2x + 1y \geq 6$

Nutrient B: $2x + 4y \geq 12$ (*)

Nutrient C: $0x + 4y \geq 4$ (*)

$x \geq 0$ (*)

$y \geq 0$ (*)

Students should then write a prescription of the target function that we want to minimize:

$$f(x, y) = 0{,}50\mathrm{x} + 0{,}60\mathrm{y} \quad \rightarrow \text{minimize (*)}$$

Students had also in this task available the figure (Fig. 9) to which they plotted the position of the straight line representing the investment.

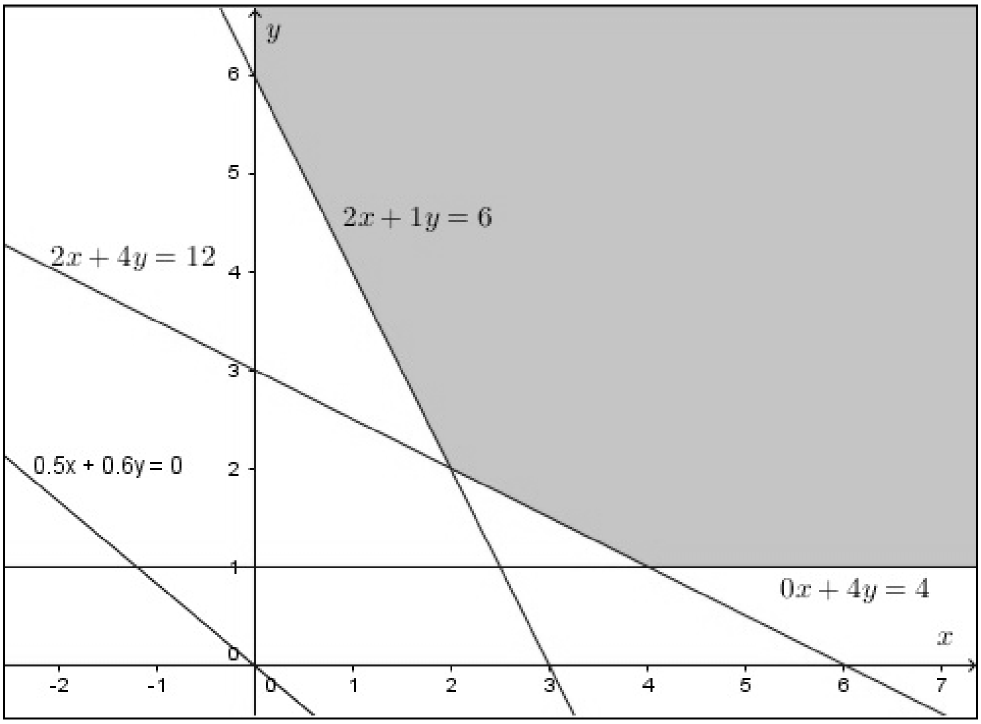

Fig. 9: Mixing of feed

Finally, have students write an answer again: One animal should be given 2 kg of feed K_1 and 2 kg of feed K_2.

Note: Students had no problem to replenish a table based on definition of the task. The problem was the change from the maximization to minimization. 3 students could not properly a trace the line and hence could not resolve an exercise. These three students does not seem to quite grasp the concept of minimizing costs for fattening. For remaining 22 students was repeated a position from the previous task. Thus, 10 students wrote an answer and of the remaining 12, only 6 enrolled an answer with whole sentence.

Task 7 (Berežný & Kravecová, 2012)

Businessman produces two types of products: product A and product B. He employs a two staff members whose productivity is about the same. Production of the one product A takes four hours and the final machining takes two hours. For the product B is nine hours for production and one hour for the final machining. Each piece of the product takes in stock 1 m^3*, and storage capacity is 12* m^3*. For production of products has a businessman maximum of 90 hours, on the final machining has a maximum of 20 hours. Profit from the sale of one product A is 65 EUR, B product is 48 EUR. How many pieces and whose products has a businessman to do that be the maximum profit?*

Note: Students had at the last task to available only the empty table that had to replenish themselves and guidelines for the further work.

First, students should replenish a table:

	Product A	Product B	Capacity
Manufacture (h)	4	9	90
Machining (h)	2	1	20
Storage (m^3)	1	1	12
Profit (EUR)	65	48	----------------
Quantity	x	y	----------------

Subsequently have the students with the help of the table write conditions (inequalities):

$$4x + 9y \leq 90$$
$$2x + 1y \leq 20$$
$$1x + 1y \leq 12$$
$$x \geq 0$$
$$y \geq 0$$

They also have to write a target function which represents a profit:

$f(x, y) = 65x + 48\mathrm{y} \quad \rightarrow \text{maximize}$

Students had to solve the task graphically using the GeoGebra and formulate an answer.

Note: The problem in this task was the preparation of the table. Some students (3) could it not and they failed to resolve (Fig. 10). Other students were able to replenish a table, and then write also a system of inequalities. Students who have achieved this first (5) solve the task using the GeoGebra on our laptop. Others were given the task to install GeoGebra at home and send us an exercise solution. All students, except those who failed to prepare a table also *sent us a solution. Again, something happened that on previous tasks, students did not write the answers.*

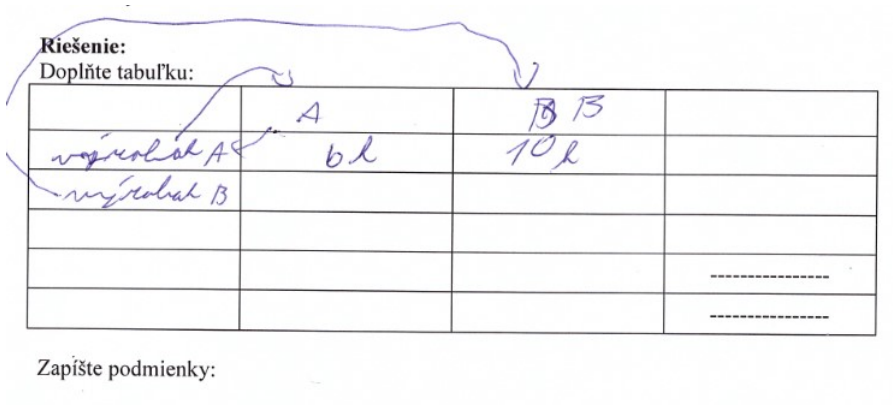

Fig. 10: Demonstration of the student solution of Task 7 - Table

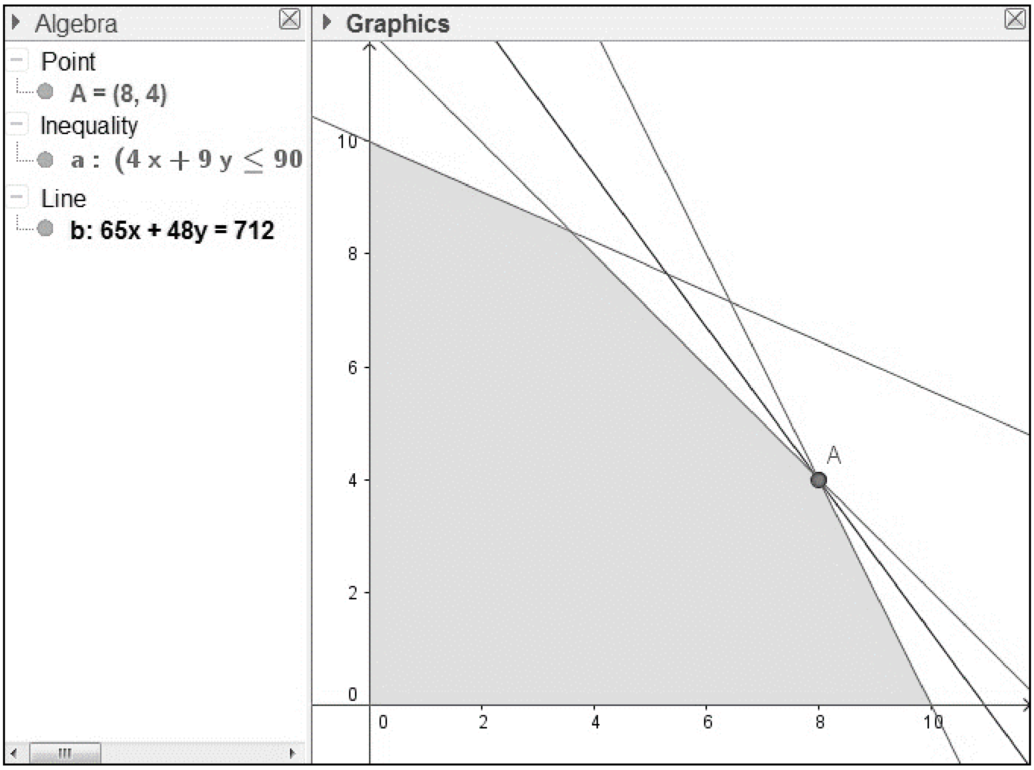

Fig. 11: Demonstration of the student graphic solution of Task 7

Results & discussion

In our experiment, the students met with the GeoGebra for the first time in their lives. Its control they mastered easily. On students was perceptible an increased activity when we allow them to work on our laptop in the last exercise. Students took the possibilities of GeoGebra because the experimental teaching took place on Friday and they sent us their solutions once on Saturday and Sunday. In doing so, we told them that there were a one week.

For the greatest benefit of GeoGebra students considered it clearness. Of course, the deeper meaning see only students who have mastered the curriculum of solutions of linear inequalities. These students especially appreciated the speed of construction, because they do not have to reside with drawing. Some students even said: "Finally, I do not exactly draw!".

Interested in working with the GeoGebra expressed mainly boys. After the lesson, the two boys asked us for other uses the GeoGebra.

The biggest positive for us was the motivating factor of the GeoGebra. Students met with the GeoGebra for the first time in their lives and it was for them something new. Of course, if they worked with the GeoGebra very often, the motivational effects would not be so high. Therefore, we think that the occasional inclusion of the GeoGebra in teaching of mathematics can be very beneficial.

The biggest problem for students were writing the verbal answers in connection with the award of task. Apparently they are not used to from a classroom teaching. Because it was a math class, then just a solving exercises was not problematic. Aside from the mentioned cases where students were unable to do a summary table. In this case, students could not select the right information from the assignment of the task. Ultimately, we evaluate the experiment as a successful. We were surprised mainly of students' interest in working with the GeoGebra.

Conclusion

The aim of this article was to introduce the reader to the possibilities, how can a dynamic geometry system (GeoGebra) use in the teaching of mathematics. The emphasis in this article is put mainly on the use of GeoGebra in other than the geometrical area. The tasks were aimed at resolving the problems of linear optimization with the help of modelling that is currently by using GeoGebra very visual and easily understandable for students.

In the current information age, students face a demanding knowledge-based economy and workplace, in which they need to deal effectively with complex, dynamic and powerful system of information and be adept with technological tools. The need to develop students' abilities to successfully use technological tools in dealing with complex solving for success beyond school has been emphasized by a number of professional organizations.

An appropriate medium for achieving this goal for students is mathematical modelling, a process that describes real-world situation in mathematical terms in order to gain additional understanding or predict the behaviour of these situations. Using the models and modelling perspective, students have opportunities to create, apply, and adopt mathematical and scientific models in interpreting, explaining and predicting the behaviour of real-world based problems.

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FLEXIBLE HYBRID LEARNING: COMPARISON OF TWO APPROACHES AND LEARNING RESULTS

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Abstract

Hybrid learning has become a widely exploited approach within the ICT-enhanced instruction. Making it flexible to students´ individual needs and preferences was the problem solved in various ways at Czech higher education institutions. In the paper two approaches to adapting the learning process to learner´s individual preferences are described comparing two different models of flexible hybrid learning. These models were exploited in educational practice and pedagogical experiments comparing learners´ knowledge in flexible and non-flexible learning were conducted. The results did not proved clearly visible differences in the two approaches, as neither numerous world-recognized researches did. Despite this, authors are persuaded that research activities in this field should go on, paying deeper attention to learners´ personal characteristics and other activities within the learning process.

Keywords

hybrid learning, pedagogical experiment, adaptive environment, flexibility, learning preferences, learning styles

Introduction

The ICT implementation within the Czech higher education system started in 1999 after the new Higher Education Law No. 111/98 Coll., §21b had become effective. The starting phase was closed in 2007 when all (i.e. 26) Czech public universities mentioned the process of ICT implementation in their annual reports. Their approaches to solving this problem were different but the analysis made by the Centre for Higher Education Studies, Prague (2006) mentions that:

- All universities emphasize the use of ICT in the process of instruction and consider it as priority.
- Technical universities, closely dealing with results of technical development, express more keen interest in the field of ICT than non-technical institutions.
- Universities differ in approaching and solving the problem of implementation: technical universities often concentrate on material and technical point of view, i.e. they put emphasis on equipment and its technical characteristics, whereas faculties of education run the slow process, but they pay more attention to didactic aspects.

Within the process of ICT implementation three institutions became the leaders and following two centres were established: (1) at the University of Ostrava (UO) and Technical University of Ostrava (TUO), which formed a joint centre; (2) at the University of Hradec Kralove (UHK), particularly the Faculty of Informatics and Management (FIM), other faculties joined the process later.

At all institutions either fully distance education, or the hybrid (blended) courses to support the full-time and part-time study programs were provided. Moreover, rather wide exchange of experience was running with surrounding countries (mainly the Slovak Republic) and with those being more experienced in this field. This fact resulted in participation in European Union projects, e.g. with Poland, Great Britain, Island, Italy, Finland, Portugal, Netherlands, Germany etc. Since 2000 the eLearning conference and competition have been held at the UHK, hosting participants from the Czech Republic and Slovak Republic, whose papers were published in the conference proceedings and best ICT-supported courses for hybrid and distance education were awarded.

This paper focuses on the problem how the process of flexible hybrid learning implementation ran at the two Czech centres. Two different approaches were applied and two different learning management systems (LMS) were exploited – a university-made LMS tailored to special needs of the institution and designed by university staff was used in Ostrava (Kostolanyova, 2012; Poulova et al., 2013; Simonova and Poulova, 2012) and LMS WebCT, currently called Blackboard, was used at FIM UHK. This study aims at following objectives:

- to summarize main concepts of ICT-enhanced teaching/learning on the basis of literature review;
- to introduce in detail the current concepts of hybrid learning at both institutions;

to present the comparison of research results collected from two hybrid learning processes conducted at two institutions.

Theoretical Background

Various approaches and terms are widely used in this field – hybrid and/or blended learning and web-enhanced or online instruction – depending on the share of information and communication technologies (ICT) in the process of instruction.

A wide consensus has not been made on the definition of hybrid learning which is also called blended learning by some authors, e.g. (Bonk and Graham, 2005; Littlejohn and Pegler, 2007;

Whitelock and Jelfs, 2003; Fong et al., 2013). The University of Washington, Bothell, defines blended courses as those where 25 % - 50 % of the traditional face-to-face class time is replaced with online or out-of-class work (Allen et al., 2007) (see figure 1), compared to the Sloan Consortium (2015), which defines the blended learning as a course where 30 % - 70 % of the instruction is delivered online.

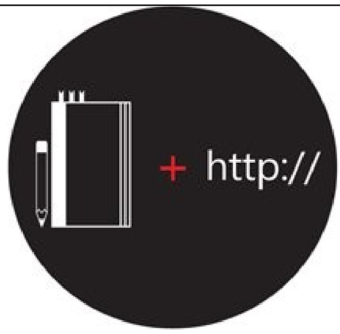
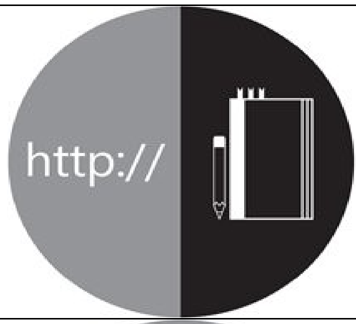
Type of course	Structure
Web-enhanced	
Hybrid	
Online	

Fig. 1: Types of courses

However, as Yamagata-Lynch (2014) claims that there is no agreed percentage of what constitutes a course as blended, and in many institutions there are idiosyncratic definitions of online, distance education, and blended instruction. Nevertheless, reflecting the share of in-class and out-of-class work we can define the blended and web-enhanced courses as those where learners have traditional class hours and use various online sources and tools to support face-to-face lessons (Allen et al., 2007).

As mentioned in several recent studies (e.g. Yamagata-Lynch, 2014; Porter et al., 2013), many more institutions of higher learning are currently showing interest in the official implementation of hybrid learning (e.g. Graham, 2006), as they consider it to be an advantage for their distance learning courses. In such a way universities can be more economical as far as the use of faculty space, time and staff are concerned (e.g. Dziuban et al., 2006). Furthermore, in other research studies (e.g. Garrison and Kanuka, 2004; Graham, 2013) ample advantages of the hybrid learning/teaching were proved, such as learning effectiveness and learners´ satisfaction.

Moreover, the hybrid learning has also undergone a shift from exploiting non-portable (immobile) devices to using mobile ones. In the past the process of implementation in the Czech Republic was limited by the fact that mobile devices were not available to such extent as in the developed countries. However, currently the situation has changed substantially, mobile devices have become available to a large extent and for reasonable prices. Consequently, mobile learning can be exploited at all levels of education Poulova and Simonova, 2012; Roschelle, 2003). Learners using mobile devices all days long for private purposes have been basically literate to use them for education. Before the process of the wide-spread exploitation of mobile devices in education started, several questions had been researched in the Czech Republic focusing on whether students were sufficiently equipped with mobile devices, for what purposes do they use the mobile devices and what is the final feedback. Briefly summarized, the results proved both a wide ownership and exploitation of mobile devices for education and education-related communication (Simonova and Poulova, 2015a).

Above all, another phenomenon is intimately connected to flexible hybrid learning, i.e. tailoring this process to learners´ individual needs and learning preferences. In spite of numerous advantages, there exist several conflicting ideas. Therefore, as widely accepted, teachers should support higher motivation and stimulation with students (e.g. Poulova and Simonova, 2012; Lee et al., 2005). Moreover, hybrid learning might also be tailored to student’s learning style preferences; it can offer more interactive ways of learning and almost immediate feedback on students’ tasks, assignments or test results. However, the clear consensus on this issue has not been reached (Poulova and Simonova, 2012; Coffield, 2004; Gregorc, 1979; Wakefield et al., 2008). Mismatching in teaching/learning styles can cause a wide range of further educational problems (Felder, 2010). Gregorc (2004) discovered that only individuals with very strong preferences did not study efficiently, the others may be encouraged to develop new learning strategies under the conditions of mismatching. Mitchell (2004) emphasizes making the educational process too specific to one user may restrict the others. Up-to-now only limited number of studies (approximately 50 %) have demonstrated that students learn more effectively if their learning style is accommodated (Coffield, 2004).

The research results in learning styles by the above mentioned authors and many others been taken into consideration, the methodology on how to implement learners´ preferences into instruction was rather deeply worked out. However, Honey was the first one who was asked the question about learning styles in e-learning. After monitoring the likes and dislikes about e-learning in the group of 242 respondents he concluded that their opinions did not differ to such extent he had expected. When drilling down into deeper analysis, another question appeared, i.e. whether people with different learning style preferences had the same things in mind when they signed up for these likes and dislikes. It seemed unlikely to him that e.g. learning 'at my own pace' would be the same for learners with different learning preferences. Honey concluded that despite his initial survey had failed to reveal e-learning styles as such, it discovered some important differences about how people approach online learning. 'One size fits all' has never worked for clothes. Why should it for e-learning?' (Honey, 2010).

In the Czech education environment the Ross and Schulz´s approach (Mares, 1998) and Gregorc´s concept (2004) were applied by Mares for the hybrid learning reflecting learning styles preferences, i.e. four types of websites were designed:

─ the concrete/sequencing,

─ abstract/sequencing,

─ concrete/random,

─ abstract/random ones.

Mares (2004) also proposed to adjust the World Wide Web to various learning styles, i.e. to sensory, social and cognitive preferences, and to design:

─ the visual Web providing static texts, images, graphs, animations, video-recordings etc.,

─ the auditory Web with recordings of lectures, music, discussions,

─ the kinesthetic Web providing hands-on activities and practical examples,

─ the Web adapted to social preferences reflected in independent, pair or team work.

He also emphasized that for each learner it is important to be aware of his/her learning style, to know the strengths and weaknesses and be provided a variety of instructional methods to choose the most suitable ones (Simonova and Poulova, 2014.

Two approaches to flexible hybrid learning

The history of ICT implementation at the above mentioned Czech institutions (University of Ostrava and Technical University of Ostrava; University of Hradec Kralove, Faculty of Informatics and Management), started at the beginning of 1990s, when shared directories started to be exploited to make study materials available to students, followed by using the e-mail service for communication between students, and students and teachers. Step-by-step other services appeared, e.g. electronic administration of credits and examinations, displaying syllabi, timetables, entrance exams results, university websites were designed etc. In 1997 the first professional virtual learning environment Learning Space was bought by FIM, in 2001 it was replaced by WebCT. At University of Ostrava, the development of LMS Barborka started, been designed by the academic staff.

At the same time first distance on-line courses were designed at FIM within European Frameworks, e.g. Tempus Project MUDILT (Multimedia and Distance Learning for Teachers) or PATTER (Public Administrators´ Training Towards EU), ECDL (European Computer Driving License). Moreover, first projects for university students were conducted, e.g. within the OLIVA Project (On-LIne VýukA, on-line learning); their main objective was to prepare both the teachers and students for e-learning in higher education. First courses were designed for subjects in the field of Informatics, Economy and Management, then in foreign languages, Psychology, Ethics etc. In November 2015 more than 310 courses were available to 5,000 UO and TUO students and more than 250 courses to 2,300 students of FIM. University of Ostrava and Faculty of Informatics and Management also solved several international projects, e.g. on the borderless education, in co-operation with other Czech and international universities (RIUS Project: Run-up of Inter-University Study; IUS Project: Inter-University Study within selected universities in the Czech Republic).

Thus it can be stated that up-to-now both students and teachers have collected rather wide experience in this field. There is no doubt, the information and communication technologies provide a wide range of tools and strategies so that each student with individual preferences can choose from and learn efficiently. The result is that the student satisfied with the process of instruction is positively motivated and able to develop the possibly highest level of knowledge in the shortest time period spending least efforts (Simonova and Poulova, 2014). To reach such a level in the real process of instruction, requirements for optimizing the teaching/learning arose, particularly the call for improving the flexibility of the process, mainly by applying the individualized approach (Poulova and Simonova, 2012).

Model of flexible hybrid learning at University of Ostrava and Technical University of Ostrava

The flexible and personalized education is a current research topic at the University of Ostrava and Technical University of Ostrava where automatic adaptive e-learning model has being exploited. The optimal adaptive process should respect students' differences in learning styles (particularly in sensory preferences in this case) and level of their knowledge and skills (Kostolanyova, 2012). On the basis of identification their personal characteristics and qualities, students are provided such study materials which reflect their learning preferences. For the adaptive e-learning model following students characteristics are monitored:

- sensory perception preferences, covering verbal, visual, auditory, kinesthetic preferences (the VARK questionnaire by Fleming and Mills was used);
- social aspects, monitoring learner´s preferences in individual, pair, or team work (the Learning Style Inventory by Dunn and Dunn was applied);
- affective aspects, particularly including inner and outer motivation (this feature was monitored by the Dunns´ Learning Style Inventory);
- learning strategies, i.e. whether learners prefer
  - system or free work (the Inventory of Learning Style by Vermunt was exploited),
  - theoretical deductions or experimenting (the Inventory of Learning Style by Vermunt was exploited),
  - analytic or holistic processes (the Thinking Style Inventory by Sternberg and Wagner were applied),
  - deep, strategic or shallow learning (the Approaches and Study Skills Inventory for Students by Entwistle was used).

Out of all above listed questionnaires the Dunns´ Learning Style Inventory was the only one which had been translated to the Czech language and gone through the process of standardization; the others were translated and piloted by 200 students of University of Ostrava and Technical University of Ostrava. Then, further activities were applied within the process of adaptive learning:

- students were provided the introductory information and practical training on how to study in online courses so that their preferences were accommodated (in this phase adequate learning strategies were also provided to students);
- the pre-test was applied to detect learners´ starting knowledge before studying the adaptive e-learning course;
- the VAKR questionnaire was applied to detect learners´ preferences;
- the adaptive online course for learners with visual, auditory and kinesthetic preferences was designed;

— the process of teaching/learning was conducted (adaptive materials were used in the phase of independent out-of-school learning, i.e. homework);

— the post-test was applied detecting students´ knowledge after the process of instruction and home preparation exploiting the adaptive online course;

— learners´ final feedback was collected.

The adaptive personalized instruction is directed by the expert system (Kostolanyova, 2012), the schema is displayed in figure 2.

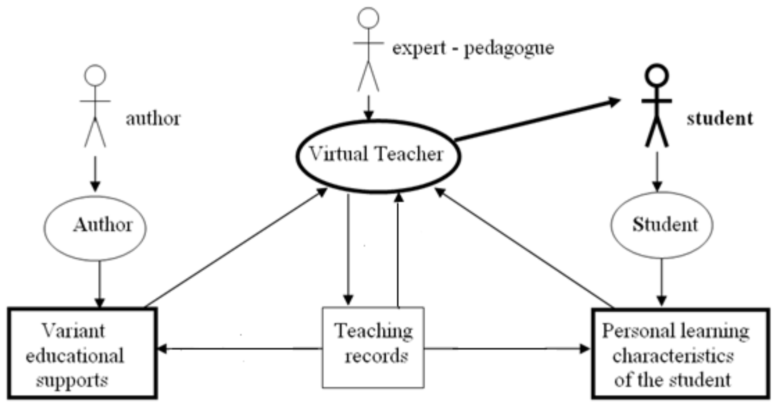


Fig. 2: Model of adaptive personalized instruction (designed by authors)

The system consists of three parts: Student, Author and Virtual Teacher. The process is student-centred.

Various types of information are required about the ´Student´ relating to the starting knowledge and learning preferences – both fields are tested before the process of adaptive learning starts, as described above (Kostolanyova, 2012).

Students with verbal preferences

— are disturbed by useless information, non-relating to the topic, within teacher´s lecturing;

— prefer independent study from books to all other teaching methods, only ´computer´ is accepted as a source of information;

— understand more from the text materials;

— always lack something important from teacher´s speech;

— like attending libraries and reading rooms;

— are not disturbed by anything when reading;

— are able to easily distinguish meanings of similar words;

— like puzzles and word games;

— can read for hours without being tired.

Students with visual (graphic) preferences

- understand more, if working with images, schemas, animations, maps, diagrams, figures, but also with tables, they use graphic tools as arrows, circles, hierarchies;
- like writing notes and highlight important parts of the text in different colours which help them remember the content. It can be summarized that they
- remember more from written notes and texts;
- keep attention for a longer period when watching, observing the speaker, situation;
- need a quiet place for work, music or noise disturb them;
- recall whole pages of texts, including colours emphasizing important parts;
- need to write notes when learning;
- sometimes do not understand and miss the point of speech;
- draw something on the paper during listening;
- have problem to keep attention in lectures;
- are influenced by surrounding colours during their learning.

Students with auditive preferences

- often speak aloud when learning;
- prefer listening to lectures, group discussions, tutorials, recordings, using mobile devices for communication;
- remember more when listening the learning content;
- do not solve problems not by thinking but speaking about them;
- do not have their written notes well-arranged;
- do not like to follow written instructions, they prefer oral ones;
- like to listen to music when learning;
- feel their eyes are quickly tired, despite they do not have any eye problems;
- sometimes confuse letters when reading;
- sometimes do not understand the body language.

Students with kinaesthetic preferences

- prefer manipulating with things, walking when learning;
- prefer practical experience, or at least examples, training, simulations, demonstrations, case studies;
- start solving the task before reading instruction;
- are not able to sit at the desk;
- watch the sample and then do it themselves;
- apply the trial – error method;

— like reading when e.g. cycling on the stationery bicycle;

— often make breaks when studying;

— often use body language and gestures;

— remember more when rewriting their notes;

— like sport activities and are good at sports in general.

Student´s characteristics also include

— social aspects, i.e. preferences to working and learning alone, in pairs, groups;

— affective aspects, i.e. incentives to inner and outer motivation, so that to detect whether they are motivated, neutral non-motivated because of lack of interest, responsibility, not understanding the learning content, or from other reasons;

— learning tactics which reflects learner´s preferences in

- been directed, or free in learning,
- ways of processing information (theoretical, or experimental),
- processes of information processing (wholistic, or detailistic),
- approaches to information processing (deep, strategic, shallow, pathologically shalow);

— regulation of learning (undirected, directed, shared direction, free direction, self-regulation).

The *´Author´* works as a modifier of student´s learning; data in this part of model are exploited for designing such study material which reflect learners´preferences. Two main aspects were taken into account: didactic principles defined by Gagné (1975) and Comenius (1948).

If the Gagné´s approach is applied into the adaptive learning process, following structure is formed (table 1):

Tab. 1: Application of Gagné´s didactic principles into adaptive learning materials

Principle	**Reflection into the adaptive study material**
Attract learner´s attention.	motivation part
Inform learners about learning objectives.	definition of learning objectives
Recall previous knowledge.	testing the starting knowledge before the adaptive e-learning
Present the learning content.	theoretical part of study material
Guide the learner through the learning content.	explanatory part of study material
Initiate and encourage learner´s performance.	practical examples
Provide feedback.	self-testing, questions, answers, practical examples
Evaluate the performance.	results of tests, key to problem solving
Improve the saving knowledge in memory, make conditions for transferring the knowledge	fixation of knowledge, revision, practising

From the didactic principles defined by Comenius five ones were applied in the process of adaptive learning, as presented in table 2.

Tab. 2: Application of Comenius´ principles into adaptive learning materials

Principle	**Reflection into the adaptive study material**
Clearness	multimedia components included in learning materials
Awareness	motivation to studying, emphasizing the exploitation of knowledge in practice
Systematicness	continuity of previous and new knowledge
Adequacy	reflecting the learner´s age and previous level of knowledge, small steps, feedback
Retention of knowledge	setting the learning objectives, meeting learner´s professional needs, practising the new knowledge and application in practice

Moreover, the Bloom´s taxonomy of educational objectives was applied within the design of the process of learning, as well as recommendations by Tollingerova within the taxonomy of tasks (Kostolanyova, 2012).

Finally, the third part of the model, the *´Virtual Teacher´,* reads information about the student´s learning preferences, level of knowledge, and has also available various types of learning materials. Considering all these data, the ´Virtual Teacher´ recommends provides the ´Student´ the optimal way of learning. Within this step pedagogic rules and didactic principles are also taken into account; the final process of learning is really individualized, i.e. tailored to student´s needs and preferences.

Model of flexible hybrid learning at University of Hradec Kralove

The approach to flexible hybrid learning conducted at FIM, UHK reflects the theory of learning styles by C.A. Johnston. She partly agrees with works by Piaget, Jung, Skinner, cognitive psychologists etc., i.e. with the tripartite theory of the mind – feelings, thoughts and behaviour. They are expressed in the processing self (i.e. cognition), performing self (i.e. conation) and developing self (i.e. affectation). Johnston describes the whole process of learning as a combination lock, where the cognition (processing), conation (performing) and affectation (developing) work as interlocking tumblers; when aligned they unlock individual´s understanding of student´s learning combination. The will lies in the center of the model, and interaction is the key. She also compares human learning behaviour to a patterned fabric, where the cognition, conation and affectation are the threads of various colours and quality. It depends on the individual weaver (learner) how s/he combines the threads and what the final pattern is (Simonova and Poulova, 2012).

Johnston designed the Learning Combination Inventory (LCI). It focuses not on the product of learning, but on the process of learning, i.e. on how to unlock and what unlocks the learner's motivation and ability to learn. Respondents´ answers to the questionnaire form the schema (pattern) consisting from four categories (Johnston, 1996):

1. Sequential processors, who are defined as the seekers of clear directions, practiced planners, thoroughly neat workers. They expect teachers to make sure all instructions are clear and were explained step-by-step, provide a model, or an example, repeat the instruction appears more times, provide students enough time, do not change instructions, display the content structure of expected outcomes, use numbering within the structure, procedure etc.
2. Precise processors, who are identified as the information specialists, into-details researches, answer specialists and report writers. They appreciate if teachers provide references to other, more detailed sources, more detailed information on instructions, work etc., provide students with detailed notes on everything what you say, pay attention to both the providing information and finishing student's work.
3. Technical processors, who are the hands-on builders, independent private thinkers and reality seekers. They work well if teachers make sure the student understands the consequences if he does not follow the instructions, perform the hands-on activities relating to the field, let students learn in the hands-on way, apply problem-solving and immediate evaluation of the activities, accept the trial-and-error approach, students will not take notes, and then they will need your advice and support to fulfil the expectation (i.e. assignment) in the paper form.
4. Confluent processors, i.e. those who march to a different drummer – creative imaginers and unique presenters. They feel free if teachers accept students will not read instructions and follow them, help them understand when their independent work is desired or acceptable, and in what situations following the instructions is strictly required, make sure students know that taking a risk in applying new approaches is appreciated, understand that some students learn more by making mistakes, discuss possible ways of doing activities and reaching targets, detect some students will have the same problems for several times, accept some students will have more ideas and consider more approaches, which may look like they are not able to finish the work and keep the deadline.

To summarize the most frequent responses, students of all types of processors do not like to be disturbed from work, and being short of time, they would like to have entertaining environment at schools, select such ways of evaluating their knowledge which do not stress but motivate them to further study.

Data collected from the LCI were exploited by the e-application which matched appropriate types of study materials to individual student´s learning style pattern. Then, the e-application reorganized the Course Content page of the online course, i.e. where the most appropriate types of study materials were listed. Learners had each topic of the learning content available in six forms:

- full texts presenting detailed information;
- short texts structured for the distance form of education,
- PowerPoint presentations;
- animations;
- video-recorded lectures;
- links to additional sources.

The LCI data were sent to the e-application in the form of four figures describing each learner´s preferences, i.e. the combination of the sequential, precise, technical, confluent learning preferences which formed the individual pattern of each learner. Each of six types of study materials was classified by four figures (-1, 0, and 1) which corresponded to four types of processors preferences (Sequential, Precise, Technical and Confluent) as follows:

- minus one (-1) means this type of study materials was rejected by the student, as it did not match the given learning style;
- zero (0) meant the student neither appreciated, nor rejected, but accepted this type of study material;
- one (1) meant this type was appreciated and matches the student´s learning style.

After the appropriateness of each type of study materials was evaluated for a single type of learning styles (Sequential, Precise, Technical and Confluent) and the individual student´s learning style was detected by LCI, all data were processed by the e-application and the Course Content page was restructured for each student reflecting his/her individual learning preferences. On this individualized page of Course Content the e-application placed various types of study materials – those which were most appropriate to student´s learning preferences were located on the top left position, those which were rejected were situated below them. Above all, the preferred types were highlighted in colour and size of the pictograms, as displayed on figure 3.

The e-application (plug-in) was implemented in the JavaScript language and inserted in the e-course directly in the source form to the Heading of the introductory page. The plug-in was activated in the student´s browser at each access to the Course Content page, and it accomplished following sequence of activities (Simonova and Poulova, 2012):

- It hides the Expand button of the Course Content in Student view of the e-course so that the student is not able to access the Course Content tree; the entire tree is not adjusted to the student´s individual learning style and contains the numeric classification of various types of study materials and other activities and tools.
- Applying the inquiry it detects the student´s ID.
- Applying the inquiry it uploads data containing classification of single study materials according to their suitability to each learning style and the evaluation (i.e. pattern) of the logged-in student according to his/her user name.
- Applying the inquiry it uploads the tree of links to single types of study materials.
- Having evaluated each type of study materials to a single learning style, and detected the individual student´s learning style, it considers and counts the adequacy (appropriateness) of the item to the learning style within the topic.
- Finally, it re-organizes the Course Content page according to the provided data and displays a newly arranged page instead of the original one.

The data should be taken from a spreadsheet, e.g. in MS Office Excel, in the CSV format, separated by semicolon. For the purpose of the Student view of the e-course the user name of each student is required to be included in the "studenti.csv" file.

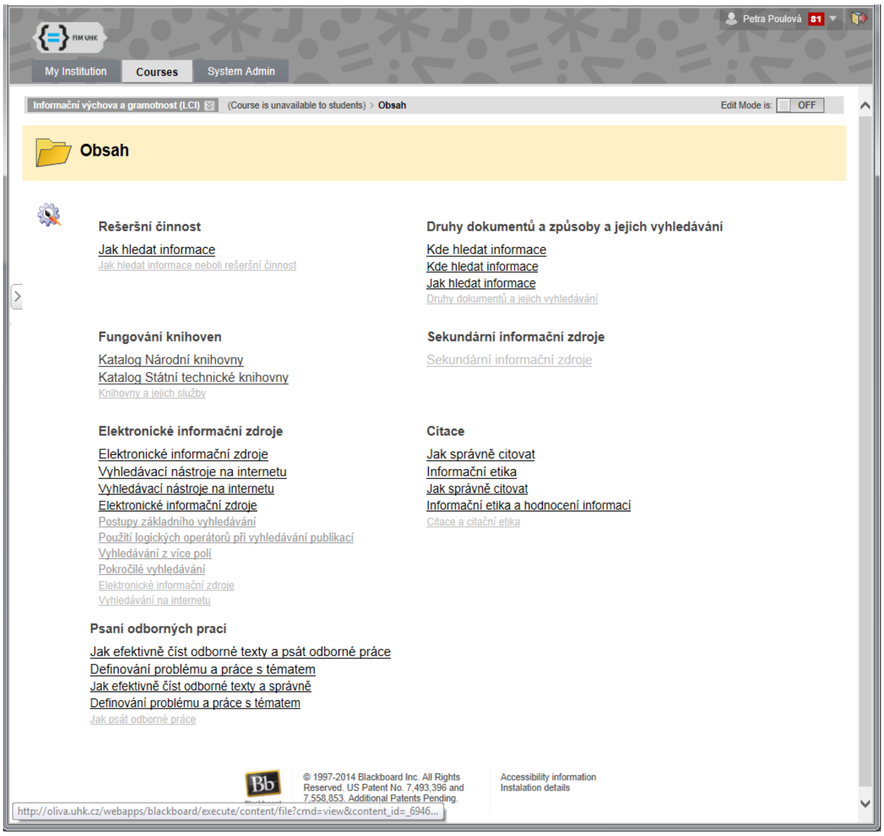


Fig. 3: Individually reorganized Course Content

Flexible hybrid learning in practice

The research on verification of both models of flexible hybrid learning by the method of pedagogical experiment was conducted in 2013/14 academic year. It followed the ´pre-test – instruction – post-test structure´. The main research objective was to answer the above mentioned question, i.e. whether students learn more if the hybrid process of instruction is tailored to their learning preferences.

Research design and results at the OU and TOU

The online hybrid course of English for Specific Purposes (ESP) was exploited for the research. Students attended two lessons per week (90 minutes), having adapted materials available in the online course for out-of-school autonomous learning.

Totally 40 students participated in this research. Students were randomly divided in two groups:

– experimental group (FEI-VAK), where the adaptive hybrid learning was applied;

– control group (FEI-CON), where no learning preferences were reflected.

The process of instruction followed the schema displayed in 3.1. Collected results are displayed in table 3 and figure 3.

	Pre-test		Post-test	
	FEI-CON	FEI-VAK	FEI-CON	FEI-VAK
Mean	5.004	5.964	7.569	8.730
Min (out of 10)	2.5	2.5	3.5	7
Max	6.5	8	9.5	10
Range	4	5.5	6	3
SD	1.37692	1.45281	1.72763	0.83142
Median	5.465	6.035	8.010	9.100
MC Sig. (1-tailed)	0.021 (Sig.<0.05) = R		0.009 (Sig.<0.05) = R	
Z-value	-2.002		-2.449	

Tab. 3: Statistic results: University of Ostrava and Technical University of Ostrava (F=0.05; FEI-CON: control group; FEI-VAK: experimental group; MC Sig: Monte Carlo Significance Test; R: H0 rejected; H0: There is no statistically significant difference between the experimental (FEI-VAK) and control (FEI-CON) groups.)

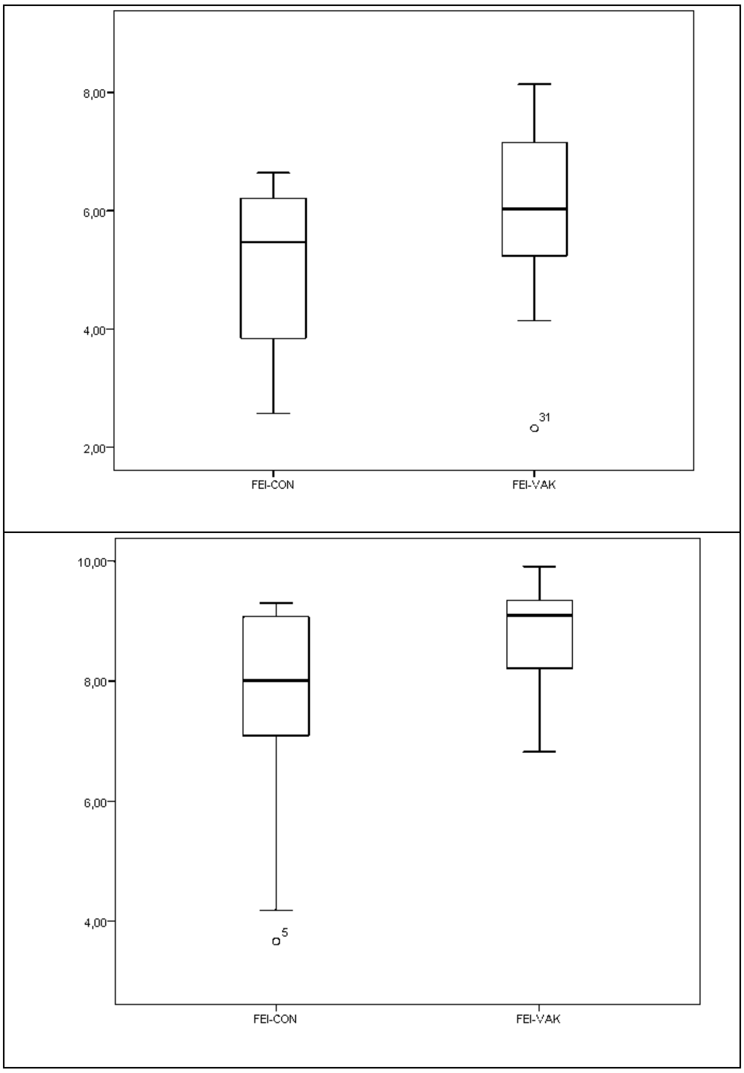


Fig. 3: Statistic results: University of Ostrava and Technical University of Ostrava

Results did not show statistically significant differences but following findings were discovered:

- both groups reached statistically significant improvement on 0.05 level (i.e. in-crease in knowledge (2.766 points in FEI-VAK group and 2.565 points in FEI-CON group; maximum score was 10 points);
- in the experimental (FEI-VAK) group the range of test scores in post-test was lower compared to pre-test;
- both groups reached rather high test score in post-tests (8.7 in FEI-VAK and 7.6 in FEI-CON);
- above all, the FEI-VAK post-test box illustrates that the adaptive hybrid approach had positive impact on learning in FEI-VAK, as the range of test score decreased compared to pre-test (bottom figure in fig. 3) and the group was more homogenous compared to the pre-test level of knowledge (upper figure in fig. 3); and, the increase in test score was higher with students who reached weak results in pre-test.

Moreover, following three aspects were important for further data processing:

- statistically significant differences were discovered between the pre-test and post-test scores in the experimental and control groups,
- normal data distribution was not detected,
- amount of participants in both groups was low (20 in each group).

These were the reasons why data were further tested by Kendall correlation coefficient. The results are displayed in table 4.

		Pre-test results	Post-test results	Increase
FEI-CON	Pre-test	1.000	0.497**	-0.106
	Post-test	**0.497****	1.000	0.400*
	Increase	-0.106	**0.400***	1.000
FEI-VAK	Pre-test	1.000	0.645**	-0.730
	Post-test	**0.645****	1.000	-0.366*
	Increase	-0.730	**-0.366***	1.000

Tab. 4: Comparison of increase in test scores (* correlation is significant at the 0.05 level (2-tailed) ** correlation is significant at the 0.01 level (2-tailed). The ´Increase´ was calculated as post-test minus pre-test result)

In the control group (FEI-CON) the statistically significant *positive* correlation was detected between the pre-test and post-test results (0.497) and the post-test and Increase results (0.400). In other words, students having higher per-test score also reach higher post-test score. *The difference between weak and excellent students was growing in the control group where no adaptation to learner´s sensory preferences was applied in the process of instruction.*

In the experimental (FEI-VAK) group the statistically significant *positive* correlation was detected between the pre-test and post-test results (0.645). The state is identical to the control group - students having higher per-test score also reached higher post-test score. But, strong *negative* correlations were detected between the post-test and Increase results (-0.366), as well as between the pre-test and Increase results (-0.730). In other words, the weak students with lower scores in pre-test reached higher increase in final knowledge compared to those with higher pre-test scores. The difference between weak and excellent students is slightly decreasing in the experimental group *where the adaptation to learner´s sensory preferences was applied in the process of instruction.*

At first sight, this result might lead us to conclusion that students with advanced knowledge (i.e. with higher pre-test scores) do not reach much development within the process adjusted to their learning preferences. This conclusion is not correct because the maximum score in the test was 10 points; students with high pre-test scores do not have enough ´space´ to show their complex knowledge (this is not the objective of testing) – the test limits are restricted to the level of knowledge required by the syllabus. Reflecting this fact we can conclude that students in the experimental group (FEI-VAK, exploiting the adaptive online course) reached better knowledge compared to those in the control group FEI-CON) who studied in the ´standard´, non-optimized one. Moreover, not only the increase in knowledge but also *acceleration* in learning with originally weak students was detected in the experimental group (table 4).

Research design and results at UHK

For the purpose of this research the online course Library services – Information competence and education was designed. Identically to the previous research, the method of pedagogical experiment was applied, and the ´pre-test – instruction – post-test´ structure was also exploited. The hybrid process of instruction included the face-to-face lessons (identically with the previous research 90 minutes per week) supported by independent study in the online course to fix and practice the learning content, develop new knowledge and be able to apply it in practice.

The sample group consisted of 324 students of University of Hradec Kralove. All students were randomly divided in three groups, each of them studying one of three versions of the same online course. The online course was provided in three versions:

1. reflecting the learner´s style (experimental group 1, online course LCI, n = 108) where the e-application was used to tailor the course;
2. providing all types of study materials to the learner; the process of selection is the matter of individual decision, the choices were tracked and compared to the LCI group (experimental group 2, online course CG, n = 103);
3. reflecting the teacher´s style (control group, online course K, n = 113) where the course was designed according to the teacher´s style of instruction.

Unfortunately, no statistically significant differences were discovered in learners´ performance in any group and test. The mean values and test scores in LCI, CG and K groups in pre-tests and post-tests are displayed in table 5 and figure 4.

	Pre-test			Post-test		
	CG	K	LCI	CG	K	LCI
Mean	22.61	22.48	22.46	26.34	25.42	26.10
Min	6	13	6	14	12	14
Max	28	28	28	30	30	30
Range	22	15	22	16	18	16
SD	3.62	3.73	3.98	2.98	4.13	2.42
Modus	24	23	-	28	28	28
Median	24	23	23	27	27	27
t-test	-0.2506 (crit. 1.9706)		-	-1.8953 (crit. 1.9706)		-
	-	0.0366 (crit. 1.9704)		-	-1.4987 (crit. 1.9704)	
K-S test	0.16648 (crit.0.086)	0.16629 (crit. 0.08)	0.14513 (crit. 0.084)	0.18753 (crit. 0.086)	0.17832 (crit. 0.08)	0.16228 (crit. 0.084)
Z-value	0.3717=NR		-	1.5995 = NR		-
		0.1826=NR		-	0.1863 = NR	

Tab. 5: Statistic results: University of Hradec Kralove (NR: H0 not rejected)

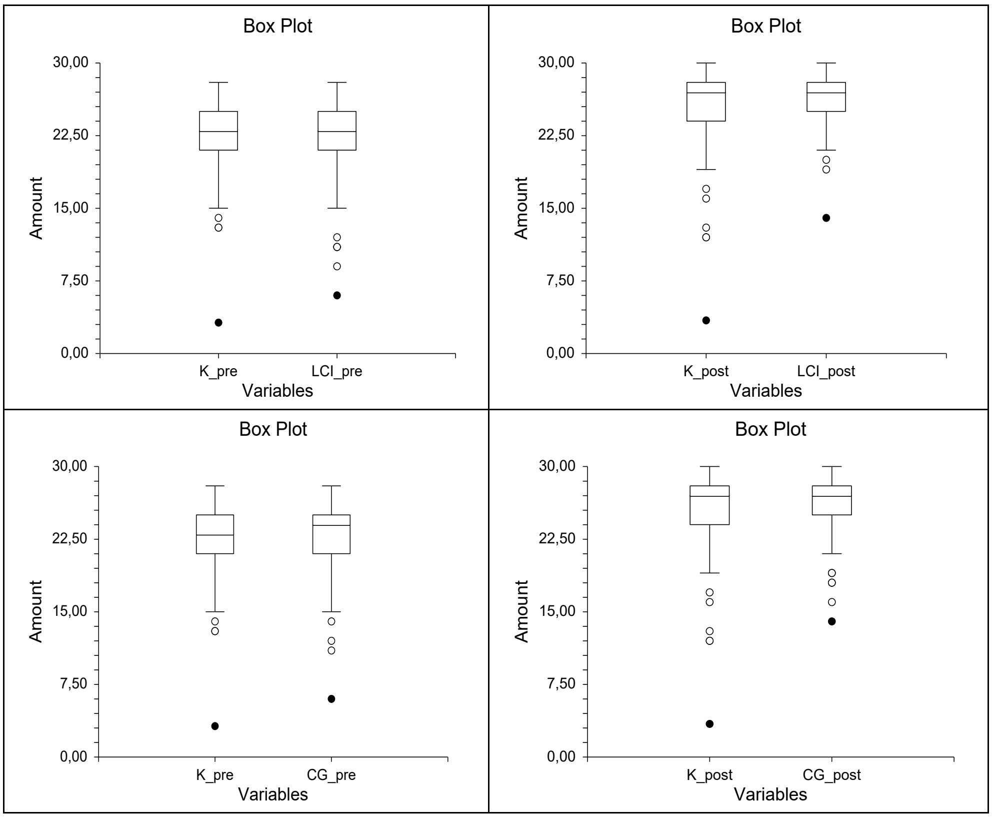


Fig. 4: Comparison of pretest and posttest test scores in LCI/K (left) and CG/K groups (right)

This result was surprising and rather disappointing for the research team. Reflecting the research results of authors mentioned above, e.g. Honey (2010), Simonova and Poulova (2012) and others) we expected, if not significant, some larger differences would be detected in the LCI group where the face-to-face learning was supported by the online course reflecting students´ learning preferences. Above all, in other researches dealing with hybrid learning which had been conducted at FIM the statistically significant differences were discovered in favour of hybrid learning, e.g. Frydrychova Klimova and Poulova (2014).
Reflecting this result, the follow-up research was conducted – closer insight in the course was applied and students´ performance was observed under several criteria Simonova and Poulova (2015b). The students´ visit rate to single tools in the course was the main criterion. It is expressed in the frequency of hits in each version of the online course. The data are displayed in table 6 and show that the Course Content was the most frequently exploited tool, i.e. more than 96 % of hits (visits) in this course were to the Course Content), which was not surprising, as study materials were available there. All materials in the Content were also available in the university library but to use those from the course might have been more convenient than borrowing them. Discussion was the second frequently used tool, but number of hits was much lower – about 5 % of students participated in discussions. The reason might have been that current discussions were held on social networks. Other tools were exploited exceptionally only. The highest number of hits made by one student was 235 times per the whole course.

Tool/Group	LCI (%)	K (%)	CG (%)
Announcements	0.76	3.59	1.90
Calendar	0.05	0.22	0.16
Course Content	96.36	89.48	88.78
Discussion	2.38	5.39	8.71
My grades	0.44	1.33	0.44
Total (n)	***5,501***	***2,784***	***4,271***

Tab. 6: Visit rate to single tools

Moreover, differences in access frequency were detected within the 20-day period, when the course was available to students. The total mean frequency was 739.8 hits per day, reaching from 254 to 1,774 hits per day. As expected, the increased number of hits was detected in the last third of the study period, when students intensified their study activities. When considering three periods within the 20-day time (starting period: days 1 – 7, middle period: days 8 – 13, final period: days 14 – 20), hardly any differences in courses were detected in the middle period, whereas increased number of hits was detected in starting and final ones. The data in all three courses show

- 19 – 29 % of hits in the starting period,
- slight decrease in the LCI and K courses and increase in the CG course in the middle period,
- sharp increase in all three courses in the final period; in the CG course the number of hits reached no fewer than 60 % of all hits detected in this course during 20 days. Details are displayed in figure 5.

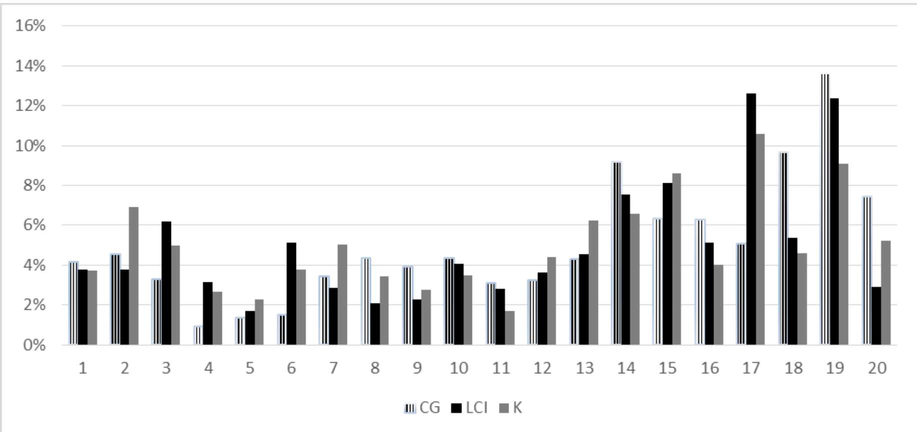


Fig. 5: Absolute frequency of hits per courseday rated to total hits in each course

Conclusions

The main objective of this research was to answer the above mentioned question, i.e. whether students learn more if the hybrid process of instruction is tailored to their learning preferences.

To sum up, within these researches the contribution of adaptive hybrid learning model was detected at the University of Ostrava, but no differences were detected in an increase in learners knowledge in the sample group of University of Hradec Kralove where the process of hybrid learning was detected in three groups reflecting/non-reflecting learners preferences. Being conscious of a small size of the research sample at UO/TOU (n = 40), the results cannot be generated. But, they prove to some limited extent that the model of adaptive hybrid learning can work. Contrary to this, the research sample at FIM UHK was rather numerous (n = 324).

Comparing these results to those reached by recognized teams, they can be considered of the same type – the contribution of flexible hybrid learning was not clearly proved.

Despite all the facts, the information about both approaches to solving this problem may be useful to those who are trying to answer the same questions; consequently, to those who are trying to find other ways to reach the target.

In both solutions ICT was used to design appropriate models of flexible hybrid learning; we consider this to be the right way for further research activities in this field.

The research results show that more detailed analysis of learner´s personal characteristics will be required, supported by their deeper reflection in tools of the hybrid learning process (assignments, tests, communication, schedule etc.).

From the results presented above it can be seen there is no definite solution. It is important for a student to be aware of his/her learning style, know what his/her strengths and weaknesses are and be provided a variety of instructional methods to choose the most suitable ones. In the days of fast technical and technological development, globalization, demand for further, lifelong education, the importance of education is increasing. These terms and conditions support the development of the whole system. Teachers´ and students´ awareness of learning styles and preferences may help substantially.

Last but not least, the development of adaptive learning systems which are able to tailor the process of teaching/learning to learner´s preferences has not been finished. The advantage of above presented approaches is they are currently being exploited in practice. The designers thus have immediate and continuous feedback from several aspects: how students are satisfied with the flexible learning, what their results are, and latest technological findings can be implemented in a short-time period. Despite students also will have different preferences and needs, future technologies are expected to help the field of education. To bring this idea into practice, the Bloom´s *Digital* Taxonomy and Communication was introduced by Churches (2015). This concept arises from the traditional Bloom´s taxonomy of educational objectives. Special attention and column is devoted to the field of Communication which is understood a crucial competence penetrating all teaching/learning activities. The concept provides a wide range of ICT-supported activities which can be used by learners of all styles.

Within the Lower Order Thinking Skills, on the Remember level students mainly focus on retrieval of information using e.g. bulleting to mark key words or phrases for recalling, bookmarking favourite web pages or sites for future use, social bookmarking and social networking, searching (googling) etc.

For the *Understand* level, i.e. interpreting, summarizing, inferring, paraphrasing, comparing, explaining etc. some procedures towards refining the newly developed knowledge can be applied, e.g. blog journaling, twittering. Both techniques can easily move beyond the understanding level to higher ones of the taxonomy if these tools are used to develop greater understanding, or to collaborate with peers, for digital organizing, classifying etc.

The *Apply* level includes implementing and using information, and executing tasks, so examples of students´ active "doing" are provided, e.g. initiating a programme and/or operating and manipulating hardware and software applications, gaming, uploading and legal sharing of materials on a site etc.

Within the Higher Order Thinking Skills, the *Analyze* level involves e.g. mashing ups, where several data sources are melded into a single set of usable information, making links within documents and web pages, but also validating the information, organizing, structuring and attributing online data etc.

The *Evaluate* level refers to verifying hypotheses, experimenting, judging, testing and monitoring, so it is place for providing informed judgments, for blog commenting and reflecting, examining materials in context, testing e-products etc.

On the highest, i.e. *Create* level students focus on designing, inventing, constructing, planning and producing, which includes e.g. finding a technology and applying it in the creative process. It could involve audio- and video-recordings, films, animations, podcasts, creating a programme application or developing a game, which results in creating completely new items.

In the extra column Churches provides the *communication* spectrum of activities from lower to higher levels: texting, instant messaging, e-mailing, chatting, networking, blogging, questioning, replying, reviewing, videoconferencing, skyping, net meeting, commenting, debating, moderating, collaborating etc.

To sum up, Churches´ work gave educators an excellent framework to begin and/or assess their digital practices. All learners, despite what their learning style is, can choose activities matching their preferences.

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INQUIRY BASED EDUCATION OF SELECTED INFORMATICS TOPICS – ANALYSIS AND RESULTS

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Abstract

In the paper we present the partial results of a qualitative research achieved in the project Innovation efficiency methods of teaching mathematics, physics and informatics (VEMIV). The project is aimed at developing inquiry skills of pupils and conceptual comprehension of the subject matter. In the first part we describe basic characteristics of inquiry-based education. In the second part we present two methodologies of teaching informatics. The first methodology is primarily focused on scientific research methods viable in school informatics. In the second one, we focus primarily on the content of school informatics. The methodologies were implemented and commented by teachers from partner grammar schools. At the end of both methodologies we summarize and analyze the results of inquiry-based education according to the presented methodologies. Our findings are supported by the results of pupils' works, the results of concepTest and evaluation feedback from teachers. In conclusion, we present recommendations for the implementation and evaluation of inquiry-based informatics education.

Keywords

informatics, inquiry-based education, methodologies, analysis.

Introduction

“Inquiry Based Science Education means pupils progressively developing key scientific ideas through learning how to investigate and build their knowledge and understanding of the world around. They use skills employed by scientists such as raising questions, collecting data, reasoning and reviewing evidence in the light of what is already known, drawing conclusions and discussing results”. (IAP, 2012)

Inquiry Based Education (IBE) aim is therefore, besides the conceptual comprehension of the curriculum, developing pupils' inquiry skills related to various stages of exploration: The formulation of the problem and planning the research, the implementation of the research, analysis and interpretation of the research results, sharing and presentation of results, application and other use of the results (Berg, 2013) (Balogová & Ješková, 2016).

A pupil may not be, and generally even is not, capable of independently beginning to realize all stages of a research cycle. Depending on the quality and quantity of information provided to the pupil we distinguish different levels IBE. Banchi and Bell indicated in (Banchi & Bell, 2008) four levels of the IBE depending on the degree of research questions' determinacy, methods and results: from Confirmation Inquiry through Structured and Guided Inquiry to Open Inquiry.

To create a structure of inquiry lessons are used models, which serve for structuring the teaching to so-called teaching cycles. Model which is often used in the practice is 5E learning cycle by Bybee (Bybee et al., 2006) defined by five stages – Engage, Explore, Explain, Extend, Evaluate.

In the frame of the project Research on the efficiency of innovative teaching methods in mathematics, physics and informatics education (VEMIV) (Lukáč, 2016) we have focused on developing methodological materials for inquiry-based education of mathematics, physics and informatics at the secondary grammar school. The project also includes verification of the proposed inquiry-based methodologies in real school conditions and their implementation into educational curricula.

In this paper we present partial results of the ongoing project VEMIV for school informatics – the results of the implementation of teaching by two of our own designed inquiry-based methodologies. The first methodology is primarily focused on scientific research methods viable in school informatics. In the second one, we focus primarily on the content of school informatics.

ACQUISITION, PROCESSING AND PRESENTATION OF INFORMATION

This methodology is primarily focused on scientific research methods feasible in environment of school informatics. It is designed for pupils in 2nd grade of the secondary grammar school (ages 16-17) and its time consumption is about from 1 to 2 months. Pupils perform a substantial part of the work outside the school hours. The pupils' task is to choose a research area that is of interest to them and wherein they would like to gain new knowledge. Subsequently they plan and carry out own research in this area according to scientific framework of a relational research. According to (Banchi & Bell, 2008) we can include thus implemented activity to Open inquiry, in terms of the level of exploration.

In this activity pupils develop primary following inquiry skills (based on Tamir & Lunetta, 1981; Fradd, 2001; Berg, 2013; Balogová & Ješková, 2016):

- Conception, planning and design of experiment
    - Formulate hypothesis or expectation to be tested.
    - Design experiment (which variables, which relationship).

    - Design observation and/or measurement procedures (incl. lab-apparatus selection; experiment set-up) for each variable.
- Implementation
    - Observe/measure.
    - Record results.
- Analysis and interpretation
    - Transform results into standard form (i.e. tables, graphs).
    - Determine relationships between variables based on e.g. graphs, tables, text,
    - Compare experimental data to the hypothesis/expectation.
    - Propose generalizations of experiment results.
    - Draw conclusion.
- Communication
    - Share and present results in front of the class.
    - Discuss/ defend results/form arguments.
    - Elaborate formal report about the gained results.

Pilot testing of the methodology took place in the school year 2014/2015. It was attended by 52 pupils and 3 teachers. We revised the methodology based on the results of the pilot testing. In ordinary run we have provided teachers improved methodology and also sample of research project realization with comments to its particular parts.

The methodology was followed by 42 pupils in 26 working groups. Overall, they were pupils from 4 classrooms and from 3 schools. The same teacher taught two classes. Until now there was comparatively low participation of pupils because of time consumption of teaching according to this methodology and also of difficulty of research work method itself.

We are aware that the number of pupils who have completed a specified methodology is too small for us to be able to generalize our findings. Thus, the following conclusions are valid only for this small group, although given the choice of schools involved in the research we can assume a certain degree of generalization.

Teachers gave us the final products of pupils' activities. In most cases, it was the spreadsheet document in which the pupils reported results and process of individual stages of their research on separate sheets. When analyzing the pupils' work, we observed how the pupils managed to meet the conditions imposed on this type of research (relational research problem), whether and how they were able to realize the various stages of research. We analyzed the results of each pupil (or of each working group) as follows:

- **Investigated area and research problem**
    - Did the pupils determine investigated area? Which?
    - Did the pupils define the research problem?
        - Is it clear, from formulation of research problem, what will be examined?

        - Does the research bring anything new?
        - Is the research problem trivial?
- **Research questions and variables of research**
    - Did the pupils define the research question?
        - How many research questions did the pupils define? Are they closed or open?
        - Are there variables in the research questions (or in research)? How many? Are they measurable?
            - Did the pupils distinguish between dependent and independent variables?
            - Did the pupils verify the impact of the independent variable on the dependent? If so, how? (e.g. chart, picture, correlation coefficient, …)
- **Hypotheses**
    - Did the pupils formulate hypotheses? How many?
        - Did the hypotheses contain the relationship between at least two variables?
        - Are the hypotheses verifiable?
- **Data collecting**
    - Extent of research
        - What is the number of questions and number of respondents (researched objects)?
    - Did data collection ensure values for each variable?
    - Are the questions in the questionnaire open or closed?
    - Did the pupils describe the process of selecting respondents (researched objects)?
- **Final report**
    - Did the pupils compile the final report?
        - Does the final report include the interpretation and the explanation of results or just "retelling" of the graphs?
    - Does the final report contain pupils' statements about the hypotheses validity?
        - Is the pupils' expression of the hypotheses validity correct?
    - Did the pupils state some new, unexpected findings?

For completeness we point out, that we provided teachers the description and the justification of every research stage. The teachers also received the results of a fictitious research, which we used as a demonstration example of research. We added comments to each stage and each part of the research. Thus, by methodology with demonstration examples, we defined the framework which enabled to realize the research.

We explained in the table 1 some of the quantitative findings that we found by the analysis of pupils' works. In the analysis, we investigated the presence of individual stages of research, or the quality of their implementation. The table contains the percentage of answers to the above questions. We have put the answers to logical questions to one of the groups: yes, partly yes and no. The answers to quantitative questions are quantified.

Question \ answers percentage (the results are rounded to integers)	yes	partly yes	no
Investigated area and research problem			
Did the pupils determine investigated area?	77	23	0
Did the pupils define the research problem?	19	4	77
Does the research bring something new?	35	23	42
Research questions and variables of research			
Did the pupils define the research question?	15	0	85
Are there variables in research questions (or in research)?	96	0	4
Did the pupils distinguish between dependent and independent variables?	42	8	50
Did the pupils use the shape of chart as the evidence of the variables dependence?	58	0	42
Did the pupils use the correlation coefficient as the evidence of the variables dependence?	42	0	58
Hypotheses			
Did the pupils formulate hypotheses?	62	35	4
Average number of hypotheses (average / median / modus)	2.65 / 3 / 1		
Did hypotheses contain the relationship between at least two variables?	46	46	8
Are the hypotheses verifiable?	85	12	4
Data collecting			
Extent of research = number of questions * number of respondents (average / median / modus)	359.85 / 218 / 60		
Did data collection ensure values for each variable?	65	27	8
Did the pupils describe the process of selecting respondents?	27	12	62
Did the pupils describe the respondents?	0	42	58
Final report			
Did the pupils compile the final report?	100	0	0

Does the final report include the interpretation of results?	31	12	58
Does the final report include “retelling” of the graphs?	96	0	4
Did the pupils comment on the hypotheses validity?	92	0	8
Is the pupils’ expression of the hypotheses validity correct?	35	23	42

Tab. 1: The analysis of pupils’ works.

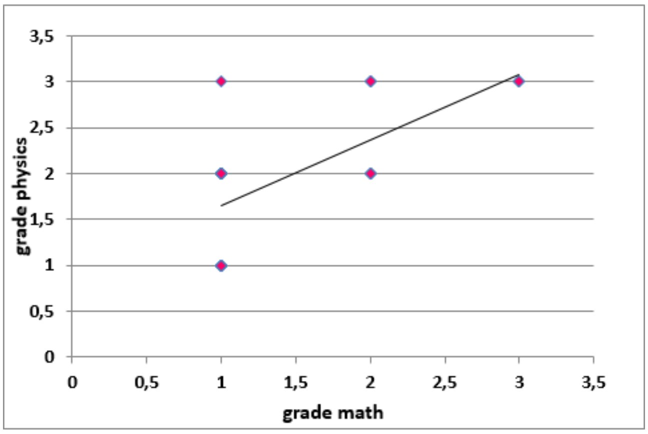
The following section attempts to explain some of the results.

Pupils chose the area of research according to their interests. We consider as a positive element that the chosen area of research is in most cases (19 of 26) beyond the content of school informatics. Among the areas of research has emerged (free translation) e.g.:

- Alcohol consumption by adolescents.
- Sporting activities and obesity.
- Young people lifestyle (active life, time spent at the computer, eating, ...)
- The impact of gender on preferences in partnership.
- Artificial Intelligence, its perception and possible threats.
- Relationship between average of grade and the numbers of hours of absence.
- Weight of woman before and after her wedding.

We assume that the pupils’ little experience and fear of failure caused that up to 58 % of research was previously almost clear that the results only confirm the already known facts.

Most pupils do not consider research questions necessary, or rather they replaced them by the question of whether there is a relationship between two variables. Half of the pupils do not distinguish between dependent and independent variable. This is probably a consequence of the previous pupils’ experience. A typical school informatics task in the spreadsheet calculator environment is to create a chart. When doing so, teachers generally do not mention which variable is independent (defaults to the first row of the table data) and which is dependent and what this property of variable means. The fact that pupils prefer the shape of the chart as proof of dependency may be related to their mathematical background. It is interesting to note, that only in 42 % of cases pupils use the correlation coefficient (Fig. 1). In 36 % of these cases its use was incorrect (e.g. correlation between eye color and IQ).



Hypothesis:
There is a relationship between the mark of mathematics and physics.

Correlation coefficient:
0,67294

Conclusion:
Hypothesis is confirmed.

Fig. 1: The part of pupils' research: Correlations between the grade of mathematics and physics.

Hypotheses are quite clearly the identifiable part of investigations of this type (97 %). But at the same time it is not so easy to formulate hypotheses correctly (46 %).

The pupils did not pay too much attention to describe the selection of respondents (researched objects). However, this could lead to erroneous interpretation of the results, and/or to incorrect generalization of the research conclusions.

Every research includes some final report, but in most cases it was just a retelling of numbers from the chart. However interpretation and explanation of the results are not so simple. Similar conclusions can be found in commentaries of the final report "The main results of PISA testing in 2012" (Šiškovič & Toman, 2014). Among the mathematical problems the tasks aimed at interpreting the results and work with charts and tables ended up as the worst. A relatively large percentage of incorrect conclusions (42 %) is probably caused by the vague formulation in research (pupil meant something and said something else), perhaps by the desire to show that the hypotheses are valid (I am right). Another reason is that pupils do not use the exact tools that would unequivocally rule on the validity of hypotheses.

When analyzing pupils' work, we found that the results of the pupils can be categorized according to their teacher. Influence of teacher to pupil was strong. We explain it by the fact that such activity is new for pupils and teachers. Pupils thus have lack of experience to build their own way, preferring to abide by what the teacher submitted to them. Since neither the teacher had a lot of experience with this type of activity, either did not comprehend or did not realize the importance of the individual stages of research. Similarly, then followed his pupils. Subsequently, his pupils proceeded similarly.

We also note that teachers slightly underestimated this subject. The realization of such research is a complex and demanding activity. It is not possible to focus on only some elements of research and neglected others. Despite the fact that pupils carried most of the work outside school hours it is necessary for teachers to keep control and guide pupils in their work. However, teachers indicated in the questionnaire that pupils were working mostly alone (Fig. 2).

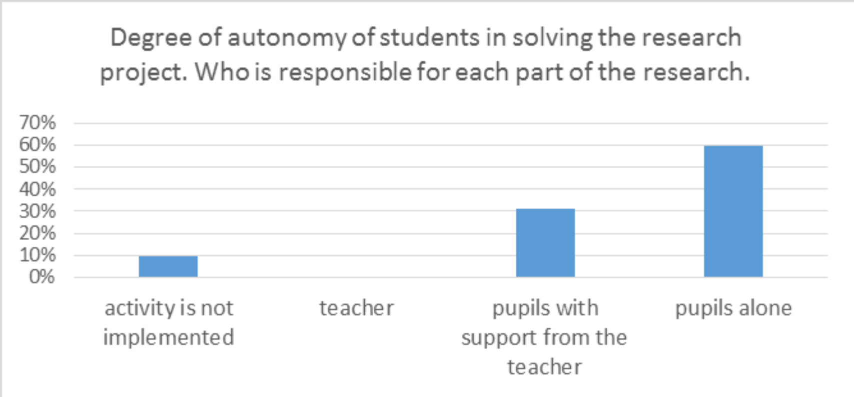


Fig. 2: Degree of pupils' autonomy in solving the research project.

We wondered how teachers assess the course of their teaching. According to the teachers this activity was quite interesting but difficult for pupils. Teachers considered their teaching as inquiry oriented with positive impact on understanding the acquired knowledge (Fig 3).

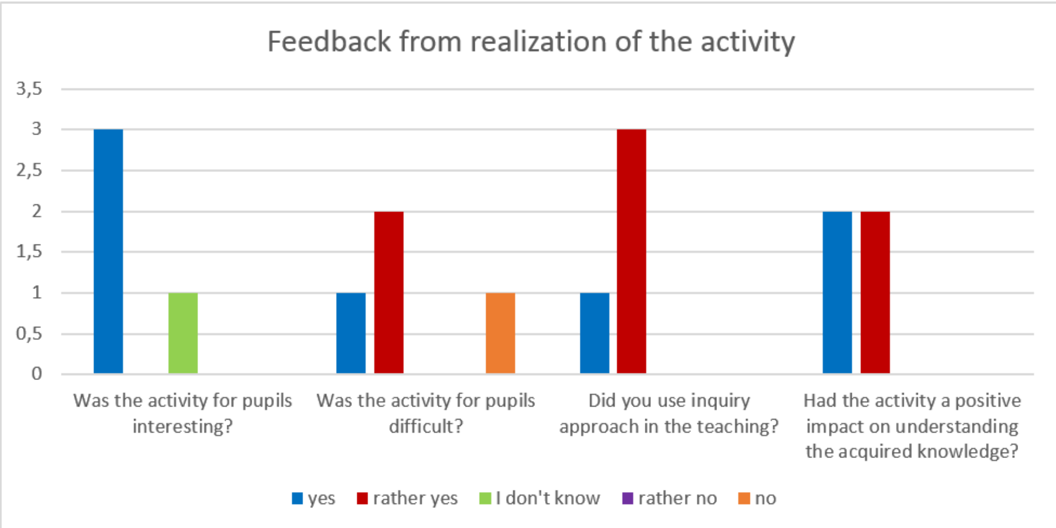


Fig. 3: Teachers' feedback from realization of the activity.

If we look at individual stages of the research problems solution, we find that the teachers realized similar activities (albeit isolated) with their pupils. E.g. the pupils are finding some values and write them to tables. Subsequently they statistically evaluated these values at the appropriate level. In most cases, however, the variables are given, the pupils only discover their values. But it is only rarely about complex problem (research problem) which requires to solve all parts in a single unit.

Although the current version of the methodology is the result of several iterations (Šnajder & Guniš, 2016), we consider that checklist appropriately guiding pupil while solving the research problem could become a part of the methodology in the future.

THE TEACHING METHODOLOGY OF THE TOPIC: THE BIT – UNIT OF INFORMATION

Next presented methodology is focused on teaching topic **The bit – unit of information**. This topic is reduced very often to the definition of the bit and the byte and calculations with byte and its multiples in our secondary grammar schools. We have updated and expanded the original version of the methodology published in (Šnajder & Guniš, 2012) to the current version that was verified at four secondary grammar schools in the school year 2014/2015 and at three secondary grammar schools in the school year 2015/2016. We suggest to teach the mentioned topic using the inquiry approach. This approach is more time-consuming in comparison to the instructive approach, but it allows pupils to understand the topic more deeply and to develop their inquiry skills by means of problem solving activities.

The structure of an inquiry methodology

Taking into account aspects of the IBE and iterative development of teaching methodologies, we proposed a specific structure of a teaching methodology (Šnajder & Guniš, 2016), that we used also for the teaching methodology of the topic The bit – unit of information.

In the section **Basic information** in addition to the standard items (e. g. topic name, target group, time allocation of a lesson, prior knowledge and skills, cognitive and affective objectives, didactic means) there is mentioned also the list of expected inquiry skills to be developed, the didactic problem, the names of the reviewers and the version of the methodology. **The didactic problem** of the topic is fact that there is insufficient space in teaching of informatics for deeper understanding of the bit as a unit of information, its identifying with the notion of a binary digit, as well as a simple calculation the amount of information in a message. Expected **inquiry skills** developed by this methodology are: experimentation, exploring the relationship between variables, justification of experimental findings, drawing conclusions.

The preparation section includes necessary teaching aids, tasks for verifying the level of prior knowledge and eventually a description of teaching methods. In the methodology we stated references for two worksheets, two applets, nine diagrams, table, concepTest (Šnajder, 2016) and set of tasks for verifying the prior knowledge of pupils.

The course of instruction is structured according to the 5E learning cycle (Engage, Explore, Explain, Extend, Evaluate) using a variety of teaching tools support (scaffolding) as recommended by IBE researchers (Bybee et al., 2006). It is defined by the following outline:

- Description of the game Guess the card (Engage) and playing the game in pairs (Explore).
- Heuristic discussion focused on discovering an effective method of determining a card (Explore) and the introduction of the concept bit as a unit of information (Explain).
- Demonstration of game with parallel guessing of 4 cards aimed at: to binary encoding of cards, to demonstrate the understanding the bit both as a unit of information and also as a binary digit, to prove the uniqueness of cards' binary encoding (Engage, Explore, and Explain).

- Practice the learned subject matter using a binary tree and its generalization at the N-ary guessing numbers or cards and extending to other information units as decits and trits (Extend).
- Summary and evaluation of the learned subject matter by self-assessment scales and concepTest (Evaluate).

The unique parts of the methodology are **The observations and findings** from teaching, which provides case studies of teaching of the author (Šnajder & Guniš, 2012) and teachers from partner schools of the VEMIV project containing percentage of particular task solutions, interesting pupils' solutions of tasks, and typical misconceptions in pupils' thinking.

The alternatives of the methodology allow a teacher to adapt the methodology to the particular conditions of teaching (e.g. his/her style of teaching, level of pupils' knowledge and skills, time allocation), and that in both direction i.e. narrowing or extension of this methodology version. It is up to teacher's competency to choose the appropriate set of tasks, levels and forms of scaffolding for pupils and level of pupils' inquiry. This methodology can be reduced to the teaching the bit as a unit of information without teaching other units (trit, decit) with fewer training tasks. The methodology can be expanded by several ways, e.g. adding tasks for other unit of information (trit, decit), pupils' programming a game for guessing number using specially prepared cards (using a binary system), discovering the relationship between the number of posed Q-nary questions and the number of cards, discovering the connection between the number of digits of Q-nary number, depth of Q-nary tree and logarithm with the base of Q, eventually to the introduction and practicing Hartley-Shannon's formula.

The methodology also includes the annex, i.e. worksheets, tables (Fig. 4), diagrams (Fig. 5), applets (Fig. 6), working files, concepTest, which are accessible for teachers on the web.

hearts, bells?	I know	hearts, leaves?	I know	J, Q, K, A?	I know	9, 10, K, A?	I know	8, 10, Q, A?	I know	binary code	decimal code
0	acorns, leaves	0	acorns	0	7, 8, 9, 10	0	7, 8	0	7	00000	0
								1	8	00001	1
						1	9, 10	0	9	00010	2
								1	10	00011	3
				1	J, Q, K, A	0	J, Q	0	J	00100	4
								1	Q	00101	5
						1	K, A	0	K	00110	6
								1	A	00111	7
		1	leaves	0	7, 8, 9, 10	0	7, 8	0	7	01000	8
								1	8	01001	9
						1	9, 10	0	9	01010	10
								1	10	01011	11
				1	J, Q, K, A	0	J, Q	0	J	01100	12
								1	Q	01101	13
						1	K, A	0	K	01110	14
								1	A	01111	15
1	bells, hearts	0	bells	0	7, 8, 9, 10	0	7, 8	0	7	10000	16
								1	8	10001	17
						1	9, 10	0	9	10010	18
								1	10	10011	19
				1	J, Q, K, A	0	J, Q	0	J	10100	20
								1	Q	10101	21
						1	K, A	0	K	10110	22
								1	A	10111	23
		1	hearts	0	7, 8, 9, 10	0	7, 8	0	7	11000	24
								1	8	11001	25
						1	9, 10	0	9	11010	26
								1	10	11011	27

Fig. 4: Table with encoding package of 32 German cards into binary system showing also equivalence of both meanings the bit (binary unit, binary digit).

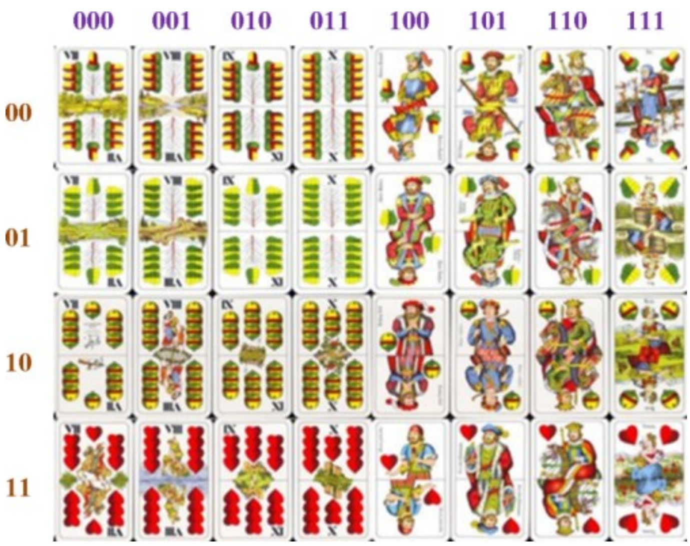


Fig. 5: Result of encoding package of 32 German cards into binary system (first 2 bits for card color, last 3 bits for card value).

Fig. 6: Applet for parallel guessing of 4 mentioned cards.

For illustration there is presented sample of two items of designed concepTest:

A message "Value of a card is 9 (from a package of 32 German cards)":

a) is 0-bit information, because we don't determine card color,

b) is 1-bit information, because we have information about exact card value, no information about card color,

c) is 2-bit information, because we still need to find out value one of 4 (=22) possible values,

d) is 3-bit information, because mentioned value is one of 8 (=23) possible values.

A message "A number has binary representation 1??10":

a) is 0-bit information, because we don't exactly determine value of mentioned number,

b) is 2-bit information, because we still need to find out 2 binary digits,

c) is 3-bit information, because we know 3 binary digits,

d) is 5-bit information, because a number consist of 5 binary digits.

Several assessment tools (e.g. pupils' worksheets and concepTest filled by pupils, interviews and questionnaires filled by teachers after their inquiry lessons) were used for evaluation of the course and the results of inquiry lessons in partner schools (especially the level of conceptual comprehension of the subject matter and level of selected inquiry skills of pupils) as well as the development of a new version of the methodology.

Analysis of research results of teaching

The methodology was implemented in school practice during two years. During the pilot run in school year 2014/2015 there were involved 34 pupils from five classes from four secondary grammar schools who verified the methodology. During the ordinary run in school year 2015/2016 there were involved 39 pupils from four classes from three secondary grammar schools, including 16 pupils in 1st grade (ages 15-16) and 23 pupils in 2nd grade (ages 16-17).

Based on the evaluation of the worksheet with 13 tasks, filled by pupils during their inquiry lesson, we have come to the following findings:

- Task 1 is focused on writing a list of questions (and answers) for guessing a schoolmate's card from package of 32 German cards. Only 21 % of pupils during pilot run solved optimally this task. After adding of the picture with cards to the worksheet in ordinary run, percentage of pupils' solution this problem increased to 44 %. Some pupils by drawing to the picture with cards narrowed a set with potential card, which helped them to find the optimal solution. In pupils' solutions new types of questions based on the pictures of cards emerged, e.g. "Is it a color of vegetable?", "Is there a man on the picture?", "Is the card on an even position?", "Is it at the third row?" or a very condensed formulated sequence of five questions "Y/R? G? >10? J/Q? A?" In another part of the task the pupils should find an optimal solution after discussion in pairs. The correct number of total questions was determined by 46 % of pupils, the number of questions for the card color by 74 % and for the card value by 59 % of pupils. It turned out that after discussions in pairs the percentage of solutions increased only slightly and also that it is easier for the pupils to determine the card color than the card value. From particular solutions of this task there can be identified certain differences among pupils in terms of their algorithmic thinking (discovering of the binary search algorithm), their systematic approach and thoroughness in their written solutions.
- Task 4, focused on the assignment of the binary code for chosen card using the same 5 questions, and was solved correctly by 97 % of pupils in both the ordinary and the pilot run. The second part of the task, focused on distinguishing both parts (for color and for value) of the binary code, was correctly solved by 53 % of pupils in the ordinary run and by 56 % ones in the pilot run. There were not registered any false solutions, but only the lack of distinguishing marks for color and value in the binary code. To obtain more accurate results about thinking of pupils, it is important to draw their attention to thorough filling of all items in the worksheet.
- Task 5 is aimed at identifying a card based on given binary code. This is a dual task for the task 4, which was suggested by pupils during the pilot run. Despite its high percentage (87 %) the task plays very important role in strengthening the subject matter.
- Task 6 focuses on declaring and proving the uniqueness of encoding the cards using binary numbers. Although 95 % of pupils correctly concluded that such encoding is unique, only 23 % of pupils approached to the correct argumentation who reported that each card has a different binary code. No pupil did prove the uniqueness of binary codes, e.g. by construction of the binary tree whose all vertices have different binary codes. This task and other ones showed very weak argumentation skills of the pupils, or low need to prove their arguments orally and all the more in writing form.
- Task 7 was aimed at constructing the binary tree as a guide for guessing an integer number ranging from 0 to 7. Only 23 % of pupils properly constructed the binary tree. 38 % of pupils did not attempt to draw a binary tree at all. This indicates that pupils not so often meet a tree structure in their learning and use it for solving problems. In further two subtasks only 44 % of pupils understood the need for asking the same number of questions for guessing integers in ranges <0, 7> and also <1, 8>. In the last subtask of task 7 and also in the task 10 only 39 % of pupils correctly determined the number of questions required for guessing a number (or a card) from set of 2K numbers (or cards). There was another pair of analogous tasks formed by the task 2

and the first three subtasks of the task 9 that increase the reliability of the results of the worksheet. In both groups of tasks 56 % of pupils correctly determined the amount of information for various messages about cards. It showed a higher percentage of pupils in determining the number of bits concerning a card color (74 %) in comparison with a card value (56 %). A surprising finding was slightly lower success rate in solving the task 9 in comparison to analogous task 2, which was likely caused by more autonomy of the pupils in solving task 9.

- Extensional tasks 11 to 13 were solved only by a few pupils with very low success rate. Individual degree of the knowledge was denoted in self-evaluation card by about 30 % of pupils for the extensional subject matter in comparison to 50 – 60 % of pupils for the basic subject matter. In the evaluation card 49 % of pupils said that the tasks were interesting for them in comparison to 14 % of pupils for whom these tasks were boring. For 35 % of pupils were the tasks difficult and for 11 % of pupils they were easy. We recommend the teachers to include 3 extensional tasks to their lesson only after their pupils successfully solved first 10 tasks, which could reduce the complexity of tasks and increase their attractiveness.

Degree of conceptual comprehension of the topic **The bit – unit of information** was verified also by the concepTest containing 10 multiple choice questions. Its publishing in the form of web form (at http://goo.gl/forms/OMxlSkfGBf) allows its availability for1 many schools and rapid evaluation of its results. In early April 2016 the concepTest was solved by 58 pupils of 1st and 2nd grade of three grammar schools participating in the project VEMIV with an average success rate of 53 % and 28 pupils of 1st and 2nd grade of two grammar schools outside the project VEMIV with an average success rate of 12 %. It is quite natural that higher percentage of success was achieved by pupils who learned the subject matter in comparison to pupils who were not involved in the topic before. Interesting, however, is very low success rate of 12 % in contrast to about 25 % which would be achieved by random answering of the pupils.

For improvement of the new version of concepTest the analysis of the test distractors can be used. 9 from 30 distractors had a lower frequency than 10 %. The distractors with the lowest rates could be removed or replaced by other ones in the concepTest. A total of 7 distractors had a higher frequency than the correct answers, which draws attention to the subject matter which should be taught more carefully in future lessons.

Other sources for analysis of teaching were the web forms in which teachers from partner secondary grammar schools reported the following observations and findings from their teaching:

- The range of teaching 90 minutes is sufficient only for the basic subject matter (first 10 tasks in the worksheet), all teachers used worksheet in their lessons but only some of them used our applets.
- The teachers considered the subject matter as rather interesting and rather difficult for their pupils. The activities connected with guessing a card were interesting for pupils, as was exemplified by the question "Do also magicians with cards use that trick with binary codes?", which was asked by a pupil to her teacher, who played the role of a magician during the lesson.

- Some teachers reported dominance of group work of pupils, others individual work, e.g. in case of some talented pupils. The teachers provided support to the pupils by guiding questions as needed. In some cases, the pupils took their initiative, e.g. helping pupils from other group or programming a card guessing game.

Summary of research results of teaching

Based on the results of worksheets and concepTest solved by pupils and also written and oral feedback from teachers on their teaching, we came to the following conclusions:

- IBE is time consuming, requiring the involvement of the pupils' and teachers' higher cognitive functions. On the other hand, solving problems in the form of magic and games provides an incentive to solve interesting problems and develop their inquiry skills.
- In supporting IBE the worksheets are of the great importance, because they determine an inquiry way of learning and teaching, they are a tool for the diagnosis and development of selected inquiry skills and also are helpful for further educational interventions. In order to achieve the most accurate results, it is important that teachers requested pupils to complete consistently their worksheets.
- Since IBE of informatics is explored too little yet, we consider it important to provide methodological support for teachers in the form of methodological materials, which sets out specific outcomes, tools, course of teaching, etc. Unconventional but very useful parts of the methodology are The observations and findings from teachers after their lessons and also The alternatives of the methodology that provide teachers with relevant know-how and ideas for the methodology modification according to themselves.
- Results of worksheets and concepTest give teachers more information about pupils' level of understanding of the subject matter and their level of inquiry skills. We consider this approach to learning and teaching as more scientific in comparison with teaching without registering results of pupils' thinking, based only on teachers' observations and their impressions.

Conclusion

Based on the previous analysis, we conclude that the teacher is a very important factor in the IBE of informatics. Despite of thoroughly prepared methodologies for teachers there were not achieved expected pupils' results. Therefore it is not sufficient to provide only a methodology and pupils' worksheets for the teacher. For quality implementation of the IBE the teacher should have sufficient theoretical knowledge and practical experience in researching and with IBE too. Moreover, the teacher should have a positive attitude towards the implementation of the IBE in his teaching.

Aims of teaching informatics are not just concepts and facts, but also the scientific procedures and methods by which informatics achieved these concepts and facts (inquiry skills).

We recommend the following three-stage process at university teacher training and further education of informatics teachers:

- a teacher in the role of inquiry pupil develops his inquiry skills,

- a teacher in the role of inquiry teacher analyzes and modifies presented IBE methodology and subsequently he implements it in his own teaching,
- a teacher in the role of the author of IBE methodology, which reflects his own experiences and suggestions for IBE of chosen informatics topics.

In this article we mentioned observations and findings from IBE of two topics of different character that do not use the same format of methodologies. We accept also other formats of methodologies. We consider formats of mentioned methodologies to be a framework for the preparation of teaching, on the other hand, these formats should not limit teachers to adapt their teaching according particular conditions.

Thanks to cooperation with didactics of physics and mathematics, which have rich knowledge and experience with IBE, we developed and implemented the mentioned methodologies into school informatics. This cooperation is very beneficial in research and implementation of IBE and STEM in education.

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THE POSSIBILITIES FOR PROVIDING INTERACTIVE CONTENT IN NEW VERSIONS OF MOODLE (FROM 3.X +)

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Abstract

LMS Moodle is (in the last 15 years) a standard part of the learning process worldwide. Its advantage is the availability, relatively easy administration and configuration and the possibility of creating so-called modules of third parties. These modules allow us to program any part of this system according to the needs and requirements of users. In this paper, we focus on modules that are not a standard part of the system, but in the last 10 years of its existence have contributed significantly to the development of intellectual, psychomotor skills and abilities of students. Some of these modules were developed by various university departments for the needs of their students, or with through bidders and enthusiasts. In this paper we point to the possibilities and results that can be achieved using such modules in the educational process.

Keywords

LMS Moodle, interactivity, modules of third parties, interactive task.

Introduction

Currently, technological and information progress extends into all areas of life, otherwise it is not in education process. Impacts of development ICT began to create new, far more progressive methods of study. Although classical full-time study has indisputable qualities and is based on direct contact with students and teachers, over time it has proved more favorable to combine this approach with new forms of education that are now presented mainly through e-learning. Aim is to provide information most effectively and therefore is necessary to take particular attention to the students. Excellent example can be a learning process when the teacher takes full advantage provided of ICT. Where teacher used in the interpretation the animations, images, or videos we can also watch the difference in activities of students and compare these results with the results of classical form of education process. Just interactivity that is provided in the environment of e-learning can motivate students and help them better understand the given issue.

The notion that learning is not simply a process of information transmission, but that students have to become actively engaged for deep learning to occur, is certainly not new (e.g., Mayer, 2001; Renkl & Atkinson, 2007). Interactive learning environments are viewed as a promising option not merely for presenting information but for allowing the learner to engage actively in the learning process (Renkl & Atkinson, 2007). Interactivity in learning is a necessary and fundamental mechanism for knowledge acquisition and the development of both cognitive and physical skills (Barker, 1994 as cited in Sims, 1996).

Since the introduction of computers as educational tools, interactivity has been heralded by many as the one feature of this technology that holds the strongest promise for educational use. (Hannafin and Peck, 1998). Interactivity makes it easy for students to revisit specific parts of the environments to explore them more fully, to test ideas, and to receive feedback. Noninteractive environments, like linear videotapes, are much less effective for creating contexts that students can explore and re-examine both individually and collaboratively (Bransford, Brown, & Cocking, 1999, p. 209). In these and many similar claims, interactivity is presented as an attribute of learning environments that enhances the quality of educational materials and that can facilitate learning.

It is highly likely that the education in the form of e-learning will continue to lead to the increasing of interactivity. Considering that the important part of education is also a test of student's knowledge, we think that is right decision ensure the highest interactivity in this area.

Methodology

Professionals in pedagogy and psychology have been dealing with the issue of employing interactive media elements within the framework of educational process for the development of students´ cognitive and intellectual capacities for a rather long time.

The importance of interactivity increased mainly after the implementation of an e-learning support of education, as its standard complement designed not only for the development of knowledge, but also students´ skills.

Interactive learning environments are viewed as a promising option not merely for presenting information but for allowing the learner to engage actively in the learning process (Renkl, Atkinson, 2007).

Among the benefits of virtual environment belongs first of all an opportunity to:

- employ elements of interactivity based on implemented interactive media elements (interactive animations, video, etc.), eventually interactive tests representing conceptual task designed for the development of psychomotor skills and abilities,
- manage his/her own course of study from the point of view of the student,
- increase motivation within the study and influence the results of learning using suitably selected methods and procedures,
- simulate conditions of the real world thus inducing situations allowing for deeper comprehension of the given problem,
- create an instant feedback,
- provide autonomy in decision making,
- verify, from the point of view of the student, various variants of solution to the given problem without a sense of threat.

Interactivity, which may dispose animations implementing in the virtual educations system, is not a characteristic the system itself, but is a result of the interaction with didactics target (Figure 1).

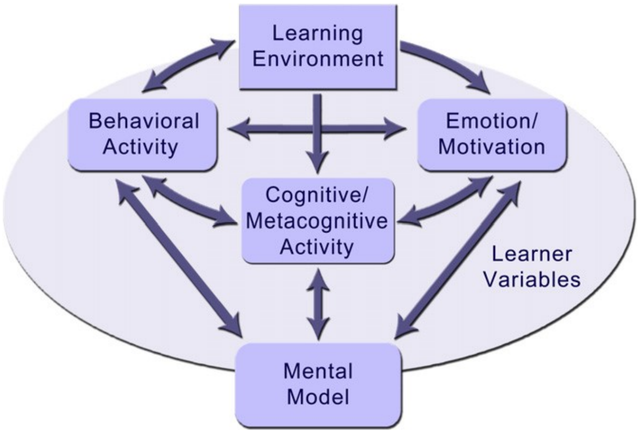

Fig. 1: Interactivity in multimedia learning – An integrated model (Domagk, 2010)

First Module - FlashQuestion

Since the end of 2009 in the Department of Informatics, Faculty of Natural Sciences (Constantine the Philosopher University in Nitra) been created or partially modified modules, which are designed to develop intellectual and cognitive abilities of students. One of the first module was modified module FlashQuestion. This module was introduced 09.07.2009 in the community that is associated to moodle.org. This module introduced russian teacher, moodle expert and chief programmer of Novosibirsk State Pedagogical University of Russia - Dmitry Pupinin. The module allows you to create interactive tests (basis is a simple flash application). The module extends the standard types of tasks implemented in a test of a completely new type of task called Flash-Movie. From the year 2015 we modified this module so, that can be embeded also HTML5 or PHP file. These files can be created as an interactive and subsequently implemented in Moodle using this module. When using the module results are automatically displayed in the final report.

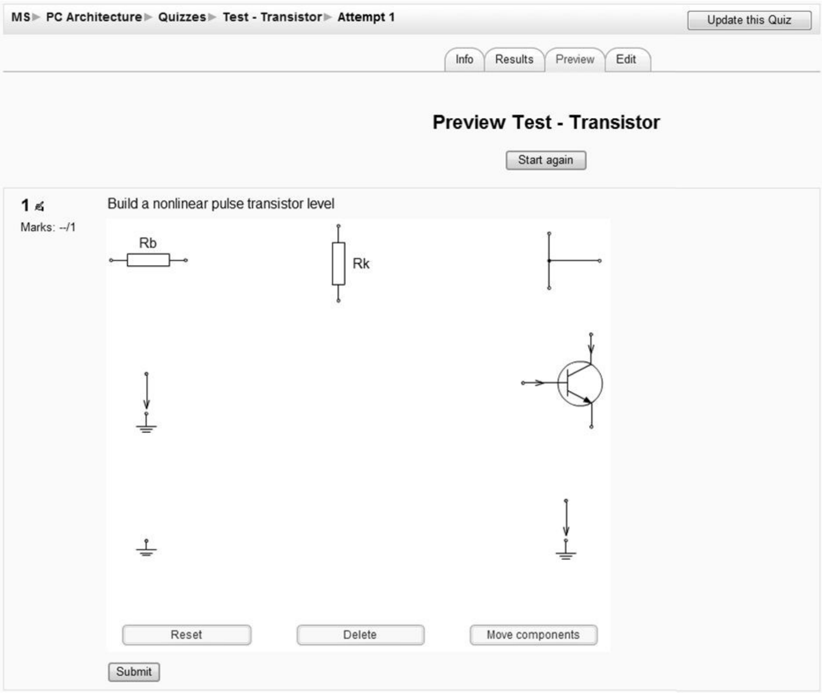

Fig. 2: The example of interactive task

Created test tasks do not include only one specific type of activity. It may contain a number of smaller tasks. If the student solves the task, the system shall assign a specific point gain. The extents, form, design and functionality created test tasks essentially depends on the imagination of the designer and his programming skills. With this type of test tasks is possible in LMS Moodle operate just as with any other type of task in LMS Moodle. Evaluation of the accuracy of the tasks, whether partial or total, takes place directly in the actual test tasks. With using module FlashQuestion is value transmitted and recorded it to the database LMS Moodle.

The module was by us gradually modified (from the version LMS Moodle 1.9 and higher) for the purpose of studying and now for Moodle version 3.XX (and higher) allows you not only to create interactive tests, but also adaptively adjust course material for conditions of students currently under evaluation obtained from tests developed. A detailed description of how the module was modified is described in the following conference papers (Magdin and Turčáni - Implementation of Interactive Animations in E-learning Courses and Their Possible Use as an Interactive Type of Question in LMS Moodle; Magdin, Turčáni and Balogh - Modelling the Transition of a Student Through an E-Learning Course Based on His Previous Activities; Cápay, Magdin and Mesárošová - Enhancement of e-Testing Possibilities With the Elements of Interactivity Reflecting the Students' Attitude to Electronic Testing).

Gradually, as the module has been modified, from the academic year 2009-2011 we conducted a series of experiments. Use these experiments we assessed the quality and method of teaching of innovative learning materials.

The aim of the first experiment was to find out the assessment of our method of teaching using innovated study materials, into which interactive animations were implemented, by the students using the e-learning course Architecture of Computers. We also tried to identify the problem items in the evaluation of the method of instruction and innovated study material. In order to assess the quality and method of teaching using the questionnaire correctly, we had to expressly define the activity of the students from the point of view of implementation and utilization of interactive animations in the e-learning course Architecture of Computers. Using this procedure we reached elimination of those items, which were irrelevant for the assessment, i.e. those, which were evaluated by the students in spite of the fact that they did not work with the given interactive animation in the course.

Experiment was carried out always in the summer term of the academic year 2009/2010 (reference group) and 2010/2011 (experimental group). At the end of the accomplished experiment students were asked to fill in the questionnaire and add some comments on what was missing or what was redundant in it.

Individual items in the questionnaire characterizing the method of instruction and interactive animations implemented into the e-learning course Architecture of Computers should have been assessed by the scale ranging from 1 to 9, where 1 meant "I fully disagree" and 9 "I fully agree". The item 5 meant "I neither agree, nor disagree". Totally, 146 students aged 18 to 50 participated (73 in academic year 2009/2010 and 73 in 2010/2011. The original number of valid questionnaires was 78, however, 5 of them were filled in spite of the fact that the students did not use the interactive animations in their course.

Our intention was to find out based on the questionnaire, whether there were significant differences in the assessment of the implemented interactive animations and the method of instruction between the reference and experimental group in individual academic years. For the evaluation of answers (item P1-P11) from the respondents the methods of descriptive statistics as well as the analysis of variance for multiple measurements with more than two levels were used.

As to the scale value means, the largest differences were found between item 9 (wording: „To comprehend the contents of education solely this e-learning course would be sufficient") and the remaining items.

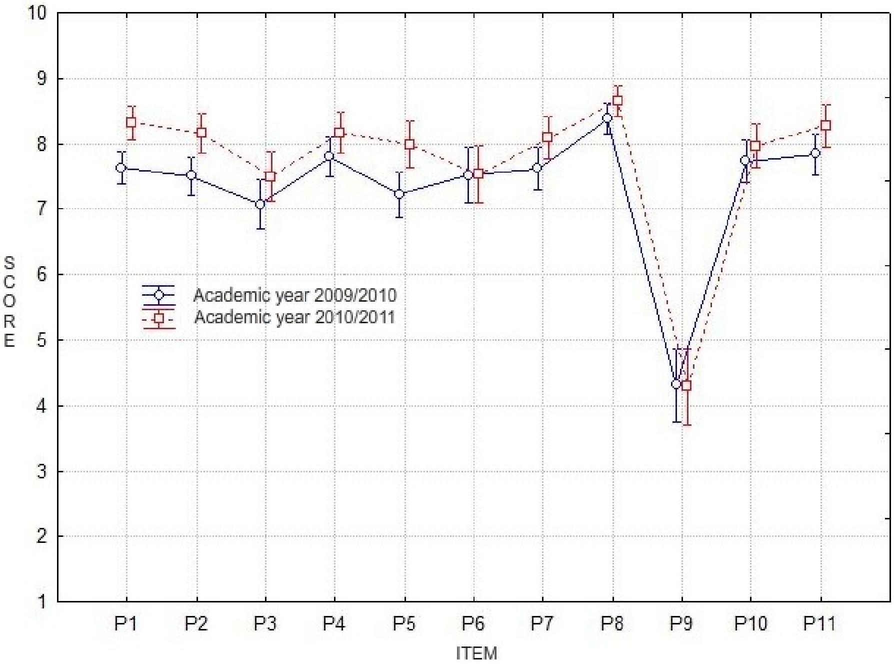

Fig. 3: Results of the experiment carried out in academic years 2009/2010 and 2010/2011

The results show that interactivity is an important and integral part of the learning system. Interactivity increases intellectual and cognitive abilities of students, but students also need feedback from the teacher. Teacher for them is certainty in communication and allows them explanations for irregularities occurring during the reading and understanding of the study material.

The second module – H5P

It is fact, that in today's digital world we increasingly need more hooks and catches to engage our students (and staff) with digital learning and despite the best efforts of many VLEs, the look, feel and layout of activities is not something most young people come rushing to use. However we can be often very frustrated with interactive content as either it is pre-designed and not quite right for the job and/or is beyond ours rather very limited programming knowledge. Interactive content creation sites are few and far to be found.

Therefore was created new module with a name H5P. This module created Svein-Tore Griff, Pål Jørgensen, Frode Petterson and Thomas Marstrander. H5P makes it easy to create interactive content by providing a range of content types for various needs, for example: games, multimedia, question or social media.

One of the great benefits with using H5P is that it gives you access to lots of different interactive content types.

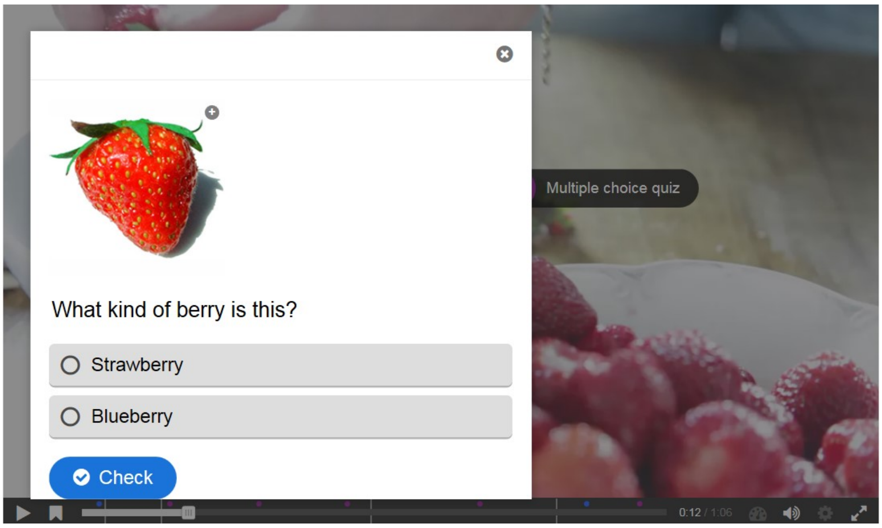

Fig. 4: Example of interactive video that we put in LMS Moodle

Another great benefit with H5P is that it allows you to easily share and reuse content. To reuse content, you just download the H5P you would like to edit and make your changes – e.g. translate to a new language or adjust it to a new situation.

H5P is:

- Open Source,
- Free to Use,
- HTML5,
- Responsive.

The H5P community is actively contributing to improve H5P. Updates and new features are continuously made available on the community portal H5P.org.

This module is perfect for beginners in LMS Moodle, because the Moodle feature is a little misleading only that the site has developed a plugin/integration with Moodle that allows data to be fed directly back to the gradebook.

Conclusion

Information technologies are explicitly or implicitly significant in all processes in our life. The development of ICT and their implementation in the educational process in the last decade, allows learners to acquire not only new knowledge and skills, but also the ability to customize the amount of study material and time to their needs.

We say that we live in a society in which ICT are becoming a driving force for its development. E-learning is obviously a part of this (Kostolányová, Šarmanová and Takács, 2011). E-learning has become an increasingly popular learning approach at universities due to the rapid growth of web-based technologies. E-learning implementation at universities is a long-lasting and complicated process. This process has to overcome a wide range of internal and external factors influencing e-learning effectiveness and content quality of learning (Drlík and Skalka, 2011).

A virtual study environment is a significant contribution to education and its role in the education industry is growing constantly [Milková, Slabý, 2006]. Basic requirements, which are imposed on LMS (Learning Management System) from the point of view of the needs of a teacher, are to present the contents of instruction, manage the instruction, communicate with students, motivate them to study, observe their progress and evaluate them [Balogh, Turcani, 2011]. Implemented multimedia applications (Java applets) in LMS together with individual approaches within the didactic process substantially influence education. They give us an excellent chance how to support not only demonstrating and visualizing the explained subject matter to be much clearer and comprehensible, but also enable us to prepare such study material for students that optimizes their study habits [Milkova, 2008a]. Multimedia applications as java applets give us an excellent chance how to support not only demonstrating and visualizing the explained subject matter to be much clearer and comprehensible, but also enable us prepare various kinds of test for students. The feedback provided through tests helps students to recognize what they already knew and what they didn't know and need to improve [Milkova, 2008b].

The implementation and use of interactive media elements in implementing the teaching process with the support of e-learning is currently among the basic methods, to encourage interactivity with the learner's learning materials so that there was a autoactivity, the development of cognitive and intellectual abilities. The foundation of good interactivity is not only well prepared hypermedia structure, but also the content of individual chapters of the e-learning course. Because only if it is possible to exploit the full capabilities of a learner, so that even to his motivation.

Actual expansion of ICT (in many ways much faster than human perception) forces us to adapt to the rate of its development. Mentioned development affects almost all areas of our existence and activities (Koprda et al., 2009). Otherwise, it is not in the educational process. Teachers are all the time looking for different ways of increasing the quality of their teaching. At present, the use of computers and new technologies has become an important aspect of education (Klimová, Poulová, 2011).

In this paper, we pointed to the possibility of providing an interactive study material that was created by means of third party modules. These modules are actively used at our Department of Computer Science from the academic year 2009.

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