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editorial

ABIDE BY THE INSTRUCTIONS FOR AUTHORS, PLEASE
Pavel Kapoun 3

articles

STIMULATION OF THE DEVELOPMENT OF INQUIRY SKILLS IN TEACHING FUNCTIONS
Stanislav Lukáč 4

DYNAMIC GEOMETRY SYSTEMS IN MATHEMATICS EDUCATION: ATTITUDES OF TEACHERS
Pavel Molnár, Stanislav Lukáč 19

ADAPTIVE E-LEARNING: FROM THEORY TO PRACTICE
Jana Šarmanová, Kateřina Kostolányová 34

ICT-SUPPORTED EDUCATION AT CZECH AND POLISH UNIVERSITIES: A COMPARATIVE STUDY
Josef Malach, Kateřina Kostolánová, Milan Chmura 48

ICT TEACHERS, SOCIAL NETWORK SITES AND ONLINE PRIVACY
Václav Šimandl 69

appendix

LET'S PLAY: THE GAMIFICATION
Petr Škuta 82

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Abide by the instructions for authors, please

Dear authors.

Unfortunately, most articles that are sent to the editorial office does not respect the instruction that are binding for publication in the ICTE Journal. They are mostly ignoring a citation standard ISO 690, but the worst is when the author “just a little bit” adapts the prescribed template. Subsequent corrections will take us great deal of time that we could give to the content and quality of the journal. All our instructions you can find on our website https://periodicals.osu.eu/ictejournal/. Thus abide by the instructions for publication in the ICTE Journal, please.

The first two articles are focused on modern methods of teaching math and science with the support of information technology. The first article discusses the stimulation of the development of inquiry skills in teaching functions and the second article analyses attitudes of teachers towards dynamic geometry systems in mathematics education.

The third article is a guide to the issues of an adaptive eLearning from theory and methodology to practical applications. The fourth article is a comparative study of ICT supported education at Czech and Polish universities.

The next two articles look into topics that are very trendy nowadays. The first one deals with teacher communication with students via social networks and the second one (the appendix) introduces a gamification method, which applies not only in marketing, but also in teaching and creating interactive educational exhibits. But are these methods in their basic principles really so ground-breaking? After all, John Amos Comenius with his textbook *Schola ludus* already was the really pioneer of gamification, was not he? Of course, except for computers.

Editors wishes to inspirational articles to readers and in return editors wishes to formally perfect articles from authors. Thank you.

Pavel Kapoun,
Executive Editor

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STIMULATION OF THE DEVELOPMENT OF INQUIRY SKILLS IN TEACHING FUNCTIONS

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Abstract

High quality mathematics and science education can induce further acceleration of scientific and technological development of society. Despite the efforts to implement modern approaches to science education, reducing the level of students' knowledge and skills is observable in some areas. The skills focused on the interpretation of data from tables and graphs and the ability to apply functions to solve problems were an important area for testing mathematical literacy in The OECD's Programme for International Student Assessment (OECD PISA) 2012. Lack of skills in the use of different mathematical functions causes problems in mathematical modelling of real situations. Our research is currently aimed at developing inquiry skills of students in mathematics and diagnosing the level of their development. Inquiry based science education (IBSE) could bring improving conceptual understanding of mathematical knowledge and could increase the activity of students in learning. In the paper, we present our first experience with testing the level of development of selected students' inquiry skills. We focus on the evaluation of tasks requiring working with different representations of data and understanding of linear functions. The paper presents also interactive learning activities that are part of our innovative methods based on applying inquiry approach to teaching linear and quadratic functions. The interactive learning activities for the investigation of the properties of functions are implemented in the dynamic geometric system Geogebra and in the spreadsheet MS Excel.

Keywords

inquiry skills, mathematics teaching, linear function, quadratic function, modelling, interactive activities

Introduction

The ability to apply the acquired knowledge to solve problems is an important mathematical competence. The development of students' abilities to solve problems requires the use of different representations of data and various types of models to express relationships between variables. Acquisition of skills in the use of simple arithmetic and graphical models is the first step in developing students' ability to use modelling in problem solving. Working with simple models provides students with skills to understand and use algebraic models, which requires identifying the variables and expressing the relationships between variables using equations, inequalities and functions.

Simple functional dependencies, such as direct and inverse proportion, are already included in teaching mathematics in the primary school. The direct proportion is a special type of linear dependence between quantities. Solving problems on linear relationship should also include the creation of tables and graphs through which various real life situations could be modelled. Suitable topics are for example tasks on motion and tasks from financial mathematics. Lack of experience in designing and interpreting charts and graphs can cause problems in understanding of symbolic representations of functional dependencies between variables. These simple models are the basis for understanding and using more complex algebraic analytical models for problem solving.

Selected results of testing mathematical skills in PISA 2012

The monitoring of mathematical literacy is the aim of several international assessments, for example TIMSS (Trends in International Mathematics and Science Study), OECD PISA. An important area of testing within PISA 2012 was solving tasks focused on the use of functions. The results from PISA 2012 show a reduction in the level of students' mathematical literacy in Slovakia (NÚCEM, 2013). Slovakia has for the first time since 2003 fallen significantly below the OECD average. Selected results show that Slovak students have gaps in working with tables and graphs and have difficulties in understanding and using functional dependencies.

Students should use the knowledge of linear function, for example, to solve tasks in the area of finance. As an example, we chose the task DVD Rental (OECD, 2013): *Jenn works at a store that rents DVDs and computer games. At this store the annual membership fee costs 10 zeds. The DVD rental fee for members is 2,50 zeds for one DVD and the fee for non-members is 3,20 zeds for one DVD.*

Question 1: *Troy was a member of the DVD rental store last year. Last year he spent 52,50 zeds in total, which included his membership fee. How much would Troy have spent if he had not been a member but had rented the same number of DVDs?*

To solve this task students can use two linear functions f: $y = 2{,}5x + 10$ and g: $y = 3{,}2x$, where x represents the number of borrowed DVDs. The function f represent the total fee for borrowed DVDs for members and the function g represent the total fee for borrowed DVDs for non-members of the DVD rental store. Using the function f students should calculate the number of DVDs that Troy borrowed last year. The function g enables the students to determine the rental fee for calculated number of DVDs, if Troy had not been a member of the DVD rental store last year. The average percentage of successful students within the OECD countries in this task was approximately 40 %.

Question 2: *What is the minimum number of DVDs a member needs to rent so as to cover the cost of the membership fee?*

Students can solve this question using several methods. The comparison of the functions *f*, *g* allows to find the value of *x*, for which the values of both functions are equal. The calculated value of *x* is approximately equal to 14,29. Therefore a member should borrow at least 15 DVDs to cover the membership fee. Students can also use logical deduction to solve the question 2. A member of the DVD rental store saves 0,7 zed on one DVD. The use of direct proportion allows to determine how many DVDs a member should borrow to cover the membership fee 10 zeds. The average percentage of successful students within the OECD countries in this task was approximately 17 %.

Students also have difficulties in understanding the symbolic representation of the relationships between variables. As an example, we chose the task about drip rate of infusion. A formula for the calculation of the drip rate, *D*, in drops per minute for infusions is:

$$D = \frac{dv}{60n}$$

d is the drop factor measured in drops per millilitre (mL), *v* is the volume in mL of the infusion, *n* is the number of hours the infusion is required to run.

29,6 % of Slovak students calculated the value of the variable *v* for the specific values of the variables *D*, *d*, *n* correctly. Only 18,1 % of Slovak students solved the task focused on a verbal description of the relationship how *D* changes if *n* is doubled but *d* and *v* do not change correctly.

The project focused on inquiry approaches to teaching of mathematics, physics, and informatics

Lack of skills in the use of mathematical knowledge in solving problems can be caused by students' lack of experience with the use of simple models for the acquisition of mathematical concepts and relationships. The low level of development of the modelling competence is often evocated by passivity of students in a memory-oriented transmissive approach to education. The innovation of "Science and Mathematics Education" is emphasized in recent documents of the European educational agencies, such as Eurydice (Eurydice, 2011).

Efforts to implement the inquiry based science education (IBSE) to school practice is reflected in a wide range of international projects supported at the level of the European Commission, or in smaller projects supported by national research agencies. In 2013, we obtained a project supported by the Agency for the promotion of research and development focused on the research on the efficiency of innovative teaching methods in mathematics, physics and informatics education. The main objective of the project is testing of innovative teaching strategies and methods in mathematics, physics and informatics education and to assess their impact on the development of students' inquiry skills and conceptual understanding.

The first phase of the project solving was devoted to design innovative lesson plans for applying inquiry approaches to the teaching of selected topics in the 1st and 2nd year of secondary school. Teachers at partner schools tested the prepared methodological and teaching materials in real school conditions in the school year 2014/2015. The teachers were given a possibility to try out the prepared teaching and learning materials based on IBSE and to test the usability of the materials for supporting the active learning. The pedagogical experiment is planned to be conducted in the school year 2015/2016.

Creating conditions for the application of inquiry approaches to learning involves also designing and implementing a stimulating learning environment in which students can experiment and explore the properties of objects and relationships between quantities. Teachers are faced with a challenge of how to use ICT to support students' inquiry. ICT provide advanced tools for visualization of functions and for the use of different modelling activities in mathematics teaching. They offer new ways of solving mathematical problems and assessing their solutions from different perspectives. ICT can facilitate independent student's inquiry or inquiry in small group but also in whole class discussion using screen projection (Goos et al., 2003). Teacher's role is to support students in using ICT in meaningful and purposeful ways. ICT can help students to explore, conjecture, construct and explain mathematical relationships. Student's inquiry is enhanced as student can, for example, drag a point in a figure or change the parameters of models (Hähkiöniemi, 2013).

In our project, we produced a variety of motivational tasks, interactive demonstrations and worksheets which should stimulate an exploration of mathematical patterns. ICT are used in learning activities to solve partial tasks from worksheets focused on investigation of mathematical relationships which students then develop and justify using logical considerations. ICT are also used to implement more complex interactive learning activities containing the sequence of tasks which enable students' active work with data and different models and which provide feedback on their learning results. To implement these learning activities, we used mainly the dynamic geometric system Geogebra and spreadsheet MS Excel.

An important indicator of the effectiveness of innovative methods is their effect on the development of inquiry skills of students. There are several classifications and schemes characterizing inquiry skills. As a convenient basis for classification and development of inquiry skills in mathematics, physics and informatics, we have chosen the scheme of inquiry skills (Van Den Berg, 2013) which issues from classifications created by Tamir, Lunetta (Tamir, Lunetta, 1981) and Fradd, Lee, Sutman, Saxton (Fradd et al., 2001). This scheme characterizes two basic methods of developing inquiry skills based on experiment or work with a model. Creation and use of models are important factors for application of inquiry approach to learning in mathematics.

This scheme contains five basic categories which are further elaborated in specific inquiry skills. We present the selected inquiry skills associated with modelling.

1. Determining the problem and planning the experiment/model:

- to formulate a question, hypothesis;
- to propose a model;

- to develop a procedure to test the hypothesis.

2. Carrying out the experiment/modelling:

- to construct a model;
- to record results.

3. Analysing and interpreting the experiment/model:

- to transform the results into transparent tables, graphs;
- to interpret results and discuss the suitability/limitations of the modelling process;
- to express relationships between variables.

4. Sharing and presenting results:

- to present results;
- to find appropriate arguments to justify relations.

5. Applying and further exploiting the results:

- to make hypotheses for further investigation;
- to apply modelling procedures to new problems.

We plan to give a pre-test in experimental classrooms at the beginning of our pedagogical experiment to assess the level of development of selected inquiry skills of students. The first trial version of the pre-test has already been given in a classroom in which the prepared lesson plans and teaching materials have not been used before. It was focused mainly on diagnosing the inquiry skills from the first and third category of the above shown scheme and on testing the clarity of the tasks and formulation of options for answers.

The first version of the pre-test contained thirteen tasks. We tried it in one classroom with 22 students in the first year at a secondary school. All tasks contained five possible answers, of which just one was correct. For illustration, we present two tasks from the pre-test focused on the application of the knowledge of linear dependence. The first task was used to diagnose the skills to interpret the relationships expressed in the form of symbolic notations.

Task 1: Given are the functions $f(x) = x + 3$ and $g(x) = 2x + 3$ defined on the set of real numbers. Choose the correct statement for given functions f, g.

a) All the values of the functions f, g are rational numbers. (0)

b) There is a real number a, for which the equality $f(a) = g(a)$ is true. (11)

c) All the values of functions f, g are positive. (2)

d) For each real number x the value of $f(x)$ is less than the value of $g(x)$. (8)

e) For each real number x the value of $f(x)$ is greater than the value of $g(x)$. (1)

The numbers written behind the individual choices for answer represent the number of students that chose the given answer. 50 % of students solved this task correctly. It can be assumed that the selection of the choice d) is induced by the incorrect idea that 2*x* must be more than *x* for each real number *x*.

The second task was used for diagnosing the rate of skills development to express relationships between variables using symbolic notations.

Task 2: Peter pays 18 € per night in camp on a trip to the mountains. Last year, he camped on average 4 nights per month. This year he bought in a national park season-ticket for 70 €, which allows him to obtain a 50 % discount for 24 nights in the camp for the entire year. Let x be the number of nights that he spent in the camp this year. Which of the following equations could we use to calculate x, given that we know the total paid by Peter for overnight accommodations at the camp?

a) $0{,}5 \cdot 18x = 862$ (0)

b) $0{,}5 \cdot 18x + 70 = 862$ (4)

c) $18x - 0{,}5 \cdot 24x = 862$ (4)

d) $18x - 0{,}5 \cdot 24x + 70 = 862$ (9)

e) $18x - 0{,}5 \cdot 18 \cdot 24 + 70 = 862$ (5)

Only 22.7 % of students solved this task correctly. The most students selected the incorrect answer d). These students intended to subtract 50 % discount from the full total amount of overnight accommodations at the camp. They did not notice that amount per one night is replaced by the variable *x* in the calculation of discount.

The average score in the pre-test was 45.98 %. This relatively low score points to the fact that some students' inquiry skills are developed on a low level. Our testing has pointed out the difficulties of students with interpretation and creation of symbolic notations expressing the relationships between variables, with making hypotheses and with finding the appropriate arguments to justify the validity of their hypotheses.

Interactive learning activities to investigate the linear dependence

Lack of skills and students' misconceptions, which we specified using the results of international measurements and research studies (for example Marshall, 2013), have been taken into consideration in designing appropriate activities and lesson plans enabling the application of inquiry approaches to teaching mathematics. We found out that students are often not able to characterize the properties of linear dependence and cannot correctly interpret the relationship between variables expressed in the form *x*/*y* = const. Therefore, we have tried to propose learning activities to explore connections between data, graphs and algebra. ICT enable students to work with tables of numbers, graphs and formulas and to link readily different representation of data. Teachers at six partner schools tested the prepared methodological and teaching materials in real school conditions in the first phase of the project solving. Proposals of teachers to reformulate questions and tasks were taken into account in the final editing of teaching materials. Teachers have highlighted the use of dynamic models to better understand the dependencies between variables and to develop the ability to use different types of models to solve real-life problems. We chose several interactive learning activities to illustrate the proposed inquiry approaches to learning linear and quadratic functions.

An interactive activity to the uniform linear motion is used to investigate direct proportion which is a special case of a linear dependence between variables. Students have the experience with uniform motion from real life and also from physics. The applet available on the address https://phet.colorado.edu/en/simulation/moving-man allows to simulate the movement of a man. A man can be moved to the house with a mouse or by running simulations of uniform motion. Figure 1 shows a simulation result for the velocity $v = 2$ m/s.

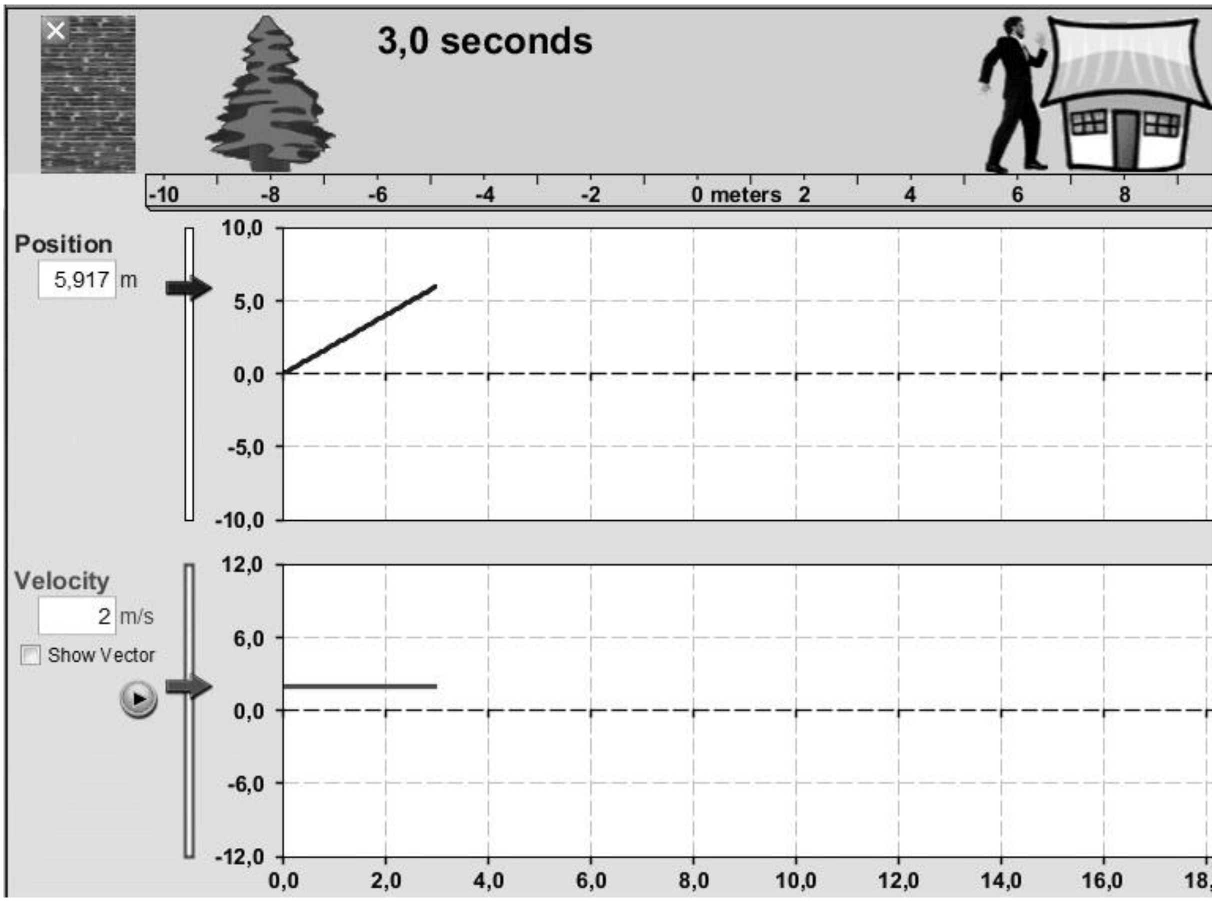


Fig. 1: The simulation of uniform motion

The simulation of the motion of the man is accompanied by drawing graphs of dependence of the distance moved and the speed over time. Horizontal lines in the Figure 1 represent time in seconds. The teacher would require students to create a table with the values of the distance moved for the selected time intervals. Student should verbally describe the relationship between distance and time and express it also using symbolic representation in the form $s/t = 2$. Then, using the applet, they could further investigate how the graphs will change for other values of the speed of a man and generalize the symbolic notation of the explored relationship.

The following activity enables students to model a linear relationship between quantities and investigate connections between different representations. The basis of the activity is a dynamic construction created using GeoGebra. To explore the linear dependence, we used a theme from real life based on the accumulation of work pieces produced in a workshop during a week. At the beginning of the week 36 work pieces have already been made in the workshop. The initial number of work pieces can be changed using the slider *a*. Workmen produce some number of work pieces each working day. The numbers of work pieces manufactured in different days of the week determine the values of the sliders *b*, *c*, *d*, *e*, *f*, *g*.

The created graph (see Figure 2) shows a dependence of the total number of work pieces produced in the workshop on time. In order to better understand the graphical representation of the modelled situation, students should create a table with data from the graph and solve two simple tasks displayed above the graph. If students enter correct numbers in the text fields they obtain information about the correctness of their answers. Then students have to set the values of sliders *b*, *c*, *d*, *e*, *f*, *g*, so that the number of work pieces in a workshop at the end of each day grows linearly over time.

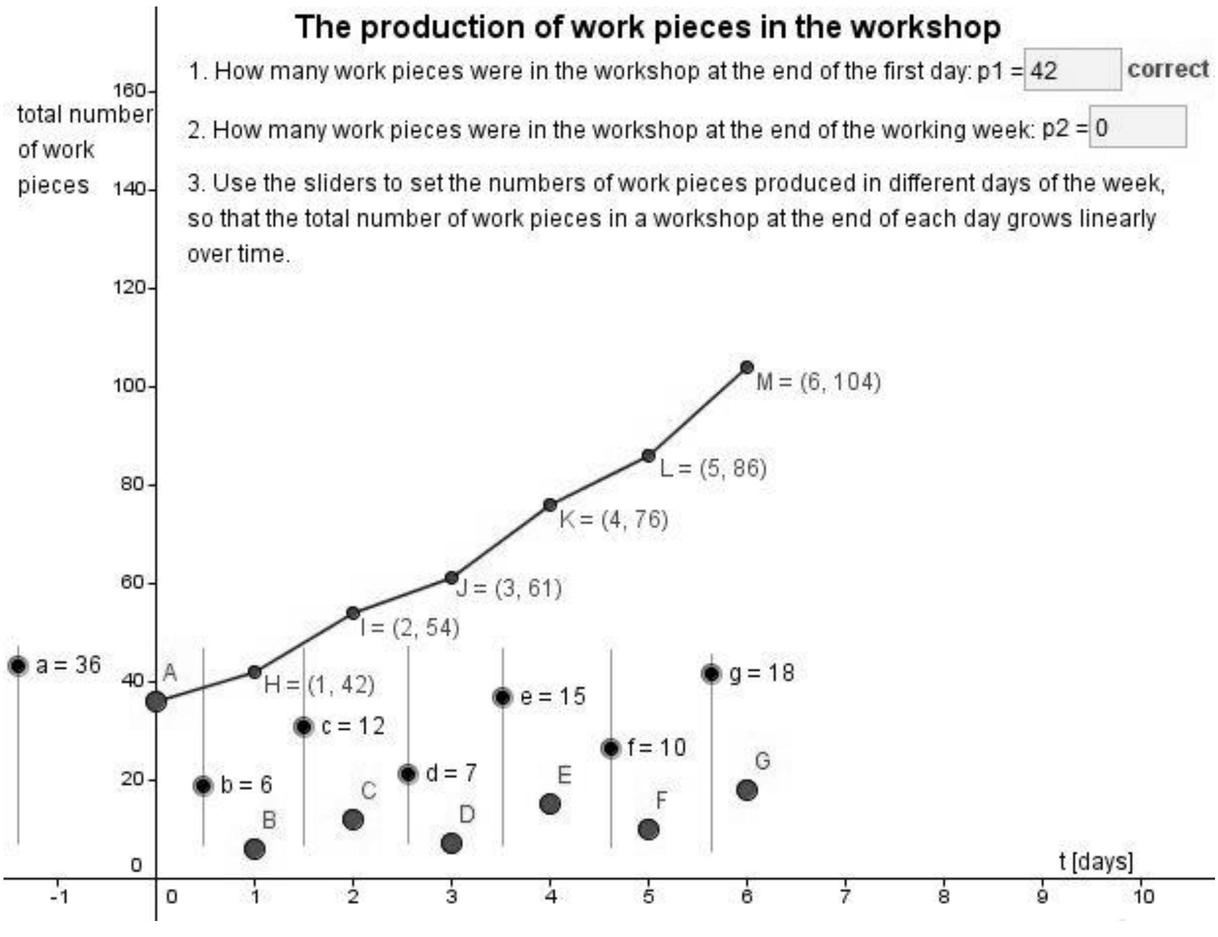


Fig. 2: The modelling of the linear dependence

Setting the same values for sliders *b*, *c*, *d*, *e*, *f*, *g* causes that the polygonal line straightens out to one straight line. Students can also change the value of the slider *a* and observe how it influences the graph of the linear dependence. After understanding the basic property of the linear dependence students can express the relationship between quantities using the formula $n = a + b.t$, where n is the total number of work pieces produced in the workshop in time t, and the variable b represents the same number of work pieces produced in different days of the week. The linear function can be generally written in the form $y = ax + b$, $a \neq 0$.

A teacher can focus students' attention to the growth rate of a linear function. If workmen produce a greater number of work pieces daily, the linear function grows faster and a line will form a larger angle with the x axis. The slope a is an important characteristic of the linear function and it can be determined using the difference $f(x+1) - f(x)$.

The proposed lesson plans include also tasks supporting formative assessment, solving of which could also provide students with self-reflection. After using the above mentioned interactive activities, we recommend to give students a task containing parts of a dialog between two boys. One boy is trying to explain to another boy that a linear function expresses direct proportion. Students have to choose one of the options: Always, Sometimes, Never and justify their choice using appropriate examples.

After modelling real life situations, we recommend to use an activity for exploring graphs of linear functions. A dynamic construction containing a graph of a linear function could be used to improve the understanding of linear functions. In accordance with the classification of the inquiry skills, this activity allows to develop also the skills associated with reasoning and generalization of discovered relationships. Students could change the values of coefficients a, b in the formula of the linear function using sliders. Students could solve the following tasks:

a) How does the graph of a linear function change if we decrease the value of the coefficient a to 0,5; –0,5; -1; ...?

b) What is the relative position of graphs of linear functions f: y = 2x – 5 and g: y = 5x + 3?

c) What is the relative position of graphs of linear functions with the same slope a?

d) Determine the coordinates of the intersection point of graphs of all linear functions given by the formula y = ax – 2, where a is any real number different from 0.

e) Find a linear function whose graph passes through the point [0, 2] and is parallel to the graph of the linear function f: y = x – 1?

f) Is there a linear function whose graph is perpendicular to the x axis?

Models for the investigation of the quadratic functions

A problem focused on triangular numbers could be used to encourage students' attention to investigation of a quadratic dependence between variables. The problem could be given to students in the form of a game. *Children were building block stairs (see Figure 3). Find out with how many blocks the stairs in few next steps are built.*

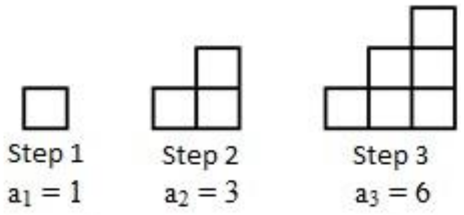


Fig. 3: The first three steps of a building of stairs

Finding the number of the blocks stairs in few following steps is an easy task. More complex problem is to identify the type of dependency between the explored variables. Students can use numerical and graphical representation of the data for problem solving. A table and mainly a graph show that the explored dependence is not linear. It cannot be expressed even by a basic quadratic function.

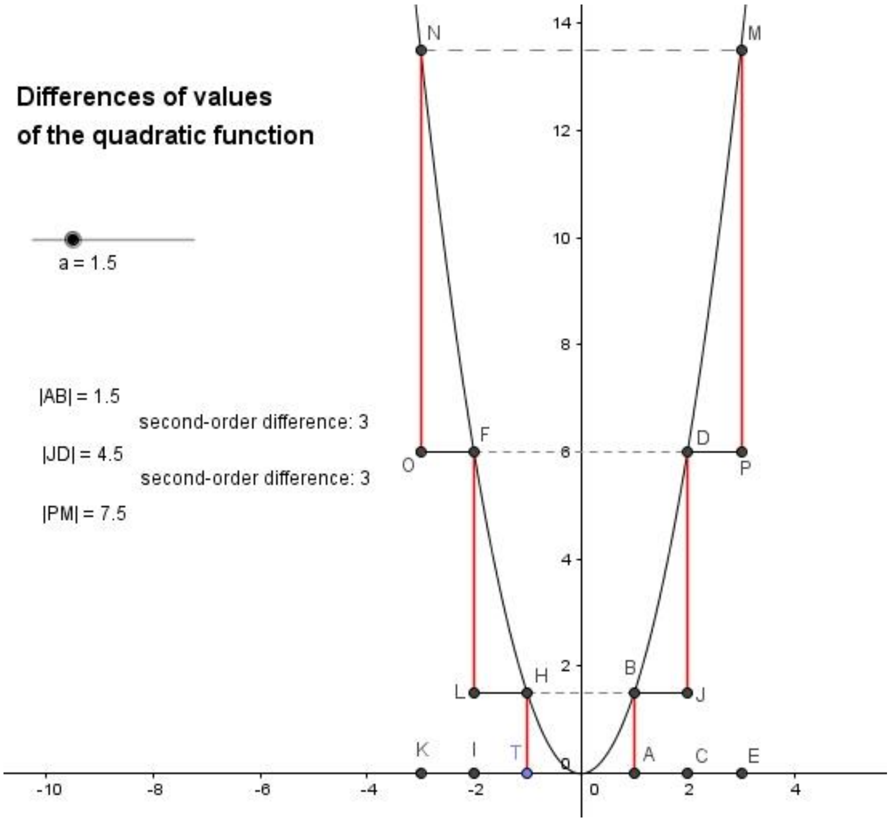


Fig. 4: The graphic model for investigation of the quadratic function

Investigation of the growth rate of selected types of functions could help students in finding a suitable type of a dependency. Teacher should focus students' attention to the growth rate of the basic linear, quadratic and cubic functions for non-negative integers. Students would create tables and graphs of functions $f : y = ax$, $g : y = ax^2$, $h : y = ax^3$, $a \in R^+$ for consecutive non-negative integers *x*. Students could find out that if the variable *x* changes by the same amount, then differences of values of the quadratic function create a linear function. A graphical model for investigating the growth rate of the quadratic function *g* would be given to students after formulating hypotheses. Figure 4 shows a graph of the quadratic function *g* for a = 1,5 and the growth rate of this function by changing the variable *x* by the same amount 1. The first and second order differences are calculated on the left from the graph of the function *g*. Students can use slider *a* for changing the value of the quadratic coefficient and for observing how the first and second order differences of values of the quadratic function change.

After investigation of the growth rate of the basic quadratic functions for integer values of the variable *x*, the teacher should focus students' attention to the changes for the values of the variable *x* which are not integer. The arithmetic model can be used to generalize the discovered findings. The model is implemented in a spreadsheet environment. It enables students to easily change an initial value of the variable *x* and the value *s* by which the variable *x* increases in each step. A part of the created table is shown in the Figure 5.

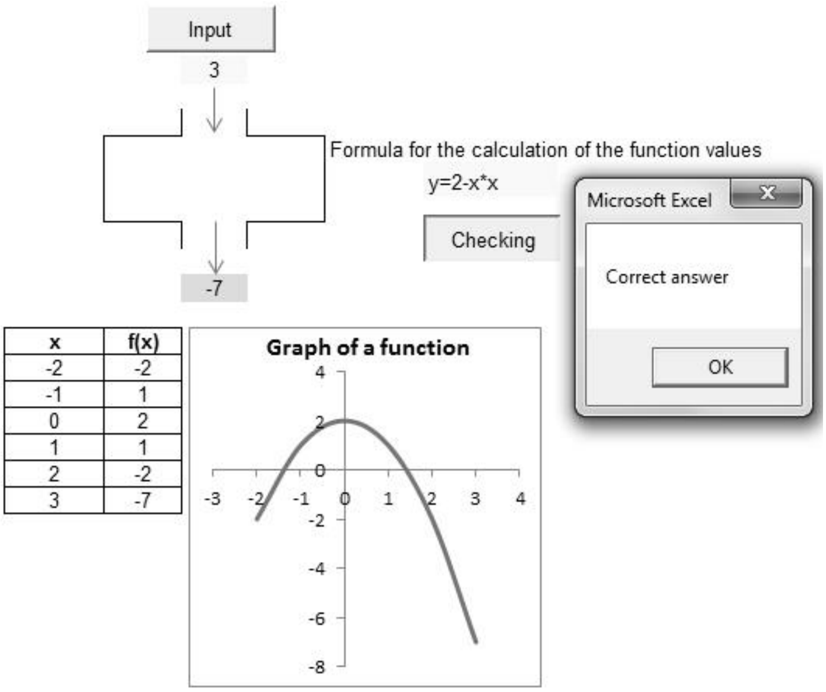
	A	B	C	D
1	Investigation of the quadratic function:			$y = ax^2 + bx + c$
2				
3	a	b	c	s
4	5	0	4	0,25
5				
6	x	f(x)	f(x+s)-f(x)	second-order difference
7	0	4		
8	0,25	4,3125	0,3125	
9	0,5	5,25	0,9375	0,625
10	0,75	6,8125	1,5625	0,625
11	1	9	2,1875	0,625
12	1,25	11,8125	2,8125	0,625
13	1,5	15,25	3,4375	0,625
14	1,75	19,3125	4,0625	0,625
15	2	24	4,6875	0,625
16	2,25	29,3125	5,3125	0,625
17	2,5	35,25	5,9375	0,625
18	2,75	41,8125	6,5625	0,625
19	3	49	7,1875	0,625

Fig. 5: The arithmetic model for investigation of the quadratic function

Using the model students can find out that if the variable *x* increases by the same value then differences of the quadratic function grow linearly. The growth rate of the quadratic function is influenced only by the quadratic coefficient *a*. Since the graph of the quadratic function is symmetrical about the axis of the parabola analogous situation occurs for decrements of the values of the quadratic function in the part of the domain in which the quadratic function is decreasing. The reasoning of the discovered properties of the quadratic function $f : y = ax^2 + bx + c$ may be based on calculating the difference $f(x + 1) - f(x)$. The result of this subtraction is the expression $2ax + a + b$ which allows to determine the linear function with the slope $2a$. Therefore, if the values of the variable x are consecutive non-negative integers, the differences of the quadratic function grow uniformly by the value $2a$. In the initial motivational problem about building block stairs the number of new blocks grows in the next step uniformly by the value 1. The number of blocks depending on the ordinal number of steps can be expressed by the quadratic function with the quadratic coefficient 1/2. The substitution of ordered pairs (0, 0) and (1, 1) into the equation of the quadratic function allows to determine the values of coefficients b, c. The searched quadratic function is $f: y = \frac{x^2}{2} + \frac{x}{2}$.

Modelling functions using the black box

An interactive activity about a black box representing an unknown formula to calculate the function values is included at the end of the part oriented on the work with different representations of linear and quadratic functions. The black box processes the input number and brings out a function value. We used a spreadsheet environment to model the black box. The interactive activity contains a sequence of eight tasks focused on finding the formula to calculate the output values of linear and quadratic functions. The formula for the calculation of the linear function values includes in some tasks the absolute value too. The last three tasks are aimed at finding formulas for the calculation of output values of the quadratic functions.



Black box representing the quadratic function

Using the Input button, students enter a value of the variable x to the box input and they receive the output value of the variable y. Students can gradually write the obtained data in the table and use it to create a graph of the explored function. Entering the correct formula and its confirmation provide access to the next sheet with a new task. Figure 6 shows the solution of the seventh task together with an additional table and a graph.

Results and Discussion

After using the prepared lesson plans, teachers filled in forms in which they expressed their subjective views on the proposed teaching and learning materials, as well as the students' reactions and their learning outcomes. The first experience shows that the use of arithmetic and dynamic graphical models helps students to interpret information from graphs correctly and to better understand the symbolic representation of relationships between variables. Most teachers highlighted the inclusion of tasks for formative assessment at the end of the selected learning activities. These tasks allow to diagnose early student's errors and misconceptions and to correct them using appropriate follow-up questions and tasks.

In the forms, teachers often emphasized that many students have difficulties with formulation of mathematical statements, with reasoning and generalization of discovered findings. Finding and using appropriate arguments to justify the mathematical statements often required a large help from the teacher. The above mentioned skills require conceptual understanding of the educational content and critical thinking.

The preparation of teachers to use innovative lesson plans in mathematics teaching and the finalization of teaching materials were carried out at the summer school for teachers. Teachers also evaluated the tasks of the pre-test and assessed the usability of tasks for developing students' inquiry skills and the complexity of tasks. The five point scale from -2 (of absolutely unsuitable) to 2 (of very suitable) was used for assessment of the tasks. Teachers' suggestions and our experience from pilot testing were taken into account when editing some tasks. For illustration, we chose the task focused on testing inquiry skill level of expressing relationships between variables using a symbolic notation (task 2). The average values of teachers' assessment of the usability and the complexity of the origin task were 1.8 and 0.6. We present the modified task 2.

Task 2: Peter pays 18 € per night in a camp on a trip to the mountains. Since he often camps out in a national park, this year he bought a season-ticket for 70 €, which allows him to obtain the 50 % discount for 24 nights in a camp for the entire year. Let x be the number of nights that he spent in the camp this year. Which of the following equations could we use to calculate the total amount s of overnight accommodations at the camp for the entire year, if we know that Peter spent in camp more than 24 nights in this year?

a) $s = 0{,}5 \cdot 18x + 70$

b) $s = 0{,}5 \cdot 18 \cdot 24 + 18(x - 24) + 70$

c) $s = 18x - 0{,}5 \cdot 24x$

d) $s = 18x - 0{,}5 \cdot 24x + 70$

e) $s = 18x - 0{,}5 \cdot 18 \cdot 24 + 70$

Students should find and express the relationship between the total amount *s* and the number *x* of nights spent in the camp. A more detailed analysis of individual answers reveals that two answers are correct (b, e). The example shows that the new version of the pre-test also includes tasks in which more correct answers are listed. Students are reminded of this fact in the introductory text at the beginning of the pre-test. Our aim is to restrict the selection of the correct answers through eliminating the false claims.

An important research question will focus on the investigation, whether the innovative lesson plans based on IBSE contribute to improving conceptual understanding. A post-test for evaluation of the effectiveness of innovative methods will be given in experimental classrooms at the end of the pedagogical experiment. The post-test will be divided into two parts. The first part will contain modifications of selected tasks from the pre-test. We will try to assess the impact of innovative approaches to teaching mathematics to develop selected inquiry skills of students. The second part will include conceptual tasks to measure the level of understanding of the educational content.

Our plan is to evaluate the learning performances of students quantitatively and also qualitatively. Quantitative analysis of the pre-test and post-test results in experimental classes of six partner secondary schools will be based on paired tests. We will evaluate whether innovative teaching methods induced a significant improvement in selected inquiry skills. Using analysis of variance (ANOVA), we will compare three groups of students with respect to their specialization: general classes, classes focusing on mathematics and classes focusing on languages. We will try to find out if potential improvements in these three groups are comparable (identical or different). In case, that ANOVA will show significant differences among the groups, Scheffe's or Tukey's method will be used to identify significant differences in pairwise comparisons.

Conclusion

Solving word problems is a convenient resource for developing the ability to apply skills of functional dependencies. The linear and quadratic dependencies can be found in real life problem solving situations that provide opportunities for creating connections between mathematics and other science subjects. Although these dependencies represent the simple types of dependencies between quantities, their understanding is necessary for acquiring more complex types of dependencies between quantities. Interactive demonstrations supplemented with asking the appropriate questions and interactive activities for students' individual investigation can assist in the implementation of the inquiry approach to teaching mathematics and science. Their contribution to teaching mathematics can be reflected in an increased student's motivation, in a development of inquiry skills and critical thinking, which is important in finding the right arguments to justify discovered relationships and their generalization.

Acknowledgments

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DYNAMIC GEOMETRY SYSTEMS IN MATHEMATICS EDUCATION: ATTITUDES OF TEACHERS

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Abstract

At present, the innovative trends in education are also often associated with the integration of ICT into the teaching process. The relationship between mathematics, teaching and computers are long-standing and complex. The actual practice of mathematics has changed its nature considerably because of the availability of powerful computers, both in the workplace and on researches' desks. Several software systems are available for mathematics teachers, among which have dynamic geometry systems a significant presence. Although various forms of education for teachers are currently organized and teachers have at their disposal a variety of learning materials and ideas for teaching, it is questionable to what extent these factors are reflected in school practice. The article describes a survey which was aimed to assess the state of the use of dynamic geometry systems in mathematics teaching at elementary and secondary schools and to find out teachers' views about suitability and possibilities of using it to improve mathematics education. The survey was conducted by questionnaire and subsequently also by interviews with teachers.

Keywords

questionnaire, interview, dynamic geometry system, GeoGebra, mathematics teaching, modelling

Introduction

Present time is characterized by rapid development of ICT that permeate all areas of social life. In today's information age, the information can be relatively easy to obtain, share and exchange. Some visionaries began to think about the use of ICT in education shortly after completion of the construction of the first computers. This idea is not to appear unrealistic given the possibilities and versatility of ICT. Seymour Papert is one of the main representatives of those policies. He is the founder of constructionism theory that characterizes the use of ICT for the formation of the internal system of knowledge the students (Papert, 1980).

ICT make its way into schools for more than 40 years. The first efforts to use ICT in education were associated mainly with testing students and with solving routine exercises focused on the training of the calculation operations. Over time have been improved a graphic and computational potential of ICT and the programmers developed a variety of software applications. A revolutionary leap in the exchange of the information meant connecting computers into the networks that allow easy acquiring and sharing information. Currently, the Internet provides a range of educational portals and interactive applications to support active learning.

Experiments in the applications of computer technology to mathematics teaching have been widespread over the last 30 years or so. The advent of fast and widespread communications such as e-mail, the internet and video-conferencing are radically changing our access to data and information. Many of the techniques associated with school mathematics were developed to solve important problems at times when tools such as electronic calculators and computers were not available. The very existence of these computational tools is now having a profound effect on the way mathematics is begin developed and applied in the world outside education. New skills of modelling, estimating, validating, hypothesizing and finding information are becoming more important than many traditional ones, such as accuracy of recall. An important issue for mathematics teachers is to ensure that their students are well prepared for their future lives and careers by gaining necessary skills, whether or not the curriculum and examination system explicitly encourage them (Oldknow et al., 2010).

So ICT can enable students to concentrate on more interesting and important aspects of content. Of course, most teachers do not have a great deal of control over the curriculum they teach. So they need to be able to apply ICT in ways that enhance the teaching and learning of the current established curriculum while also seeking to bring out some of the important relationship between mathematics and computer technology. The role of ICT in the teaching and learning process is not just confined to uses such as an "electronic blackboard" to assist in a teacher's exposition, or for "hands-on" use by students working at a task, important as both those applications are. The technology may aid the teacher in the preparation for a lesson, e.g. in gathering data, or preparing materials. It may also have a role to play in the assessment of students' learning (Oldknow et al., 2010).

In this paper, we focus on dynamic geometric systems (DGS) which provide various tools for mathematics education. The first DGS were developed early 80s of last century. One of the first applications of this type has been Geometric Supposer. On the present, GeoGebra is the most widespread DGS in the mathematics education. GeoGebra is created in the Java programming language and it is independent of the software platform. The created dynamic constructions can be easily published on the Internet in the form of applets. The name GeoGebra indicates that this program is a complex system integrating tools of geometry and algebra. This dualism can be seen mainly in the equivalence of two basic ways of defining geometric objects: geometric construction in a graphical window and insertion of an analytical representation of the object in the input line.

Markus Hohenwarter began in 2001 to develop software GeoGebra, but the team gradually extended to other programmers. The creators of GeoGebra continue its development and constantly replenished with new features and modules. In an attempt to create a complex mathematical program was implemented in the system GeoGebra module for computer algebra systems (CAS). The current version (version 5.0) enables users to present a window on the 3D geometry that allows to work with objects in three-dimensional coordinate system. Markus Hohenwarter (Hohenwarter, Lavicza, 2007) called on mathematics teachers at least to try GeoGebra system although they do not yet have experience of using ICT in mathematics teaching. Our experience of education of mathematics teachers shows that if they acquire the basics of working with GeoGebra, then they try to present their skills to students. They used GeoGebra mainly to demonstrate mathematical relationships or to solve mathematical problems. However GeoGebra provides possibilities to develop inquire skills of students. In the next section we present three ideas for modelling activities for independent students' work.

Modelling activities using the DGS

The application of innovative trends in mathematics teaching may also include modelling activities to stimulate active learning based on the investigation and discovery of mathematical relationships. We present some proposals of modelling activities from different areas of mathematics that could be used in mathematics teaching already at primary school. The main focus is on visualizing mathematical objects and relationships which could contribute significantly to the development of students' mathematical knowledge and improve understanding of mathematical concepts.

The first activity can be used to investigate symmetry of geometric shapes. It enables students to explore the images of the right triangle in axial and central symmetry for different position of an axis of symmetry or a centre of symmetry. Students should focus not only on observing relative positions of the right triangle and its image, but also on the possibility of creating a variety of specific types of quadrilaterals. The kite and parallelogram are formed in Figure 1.

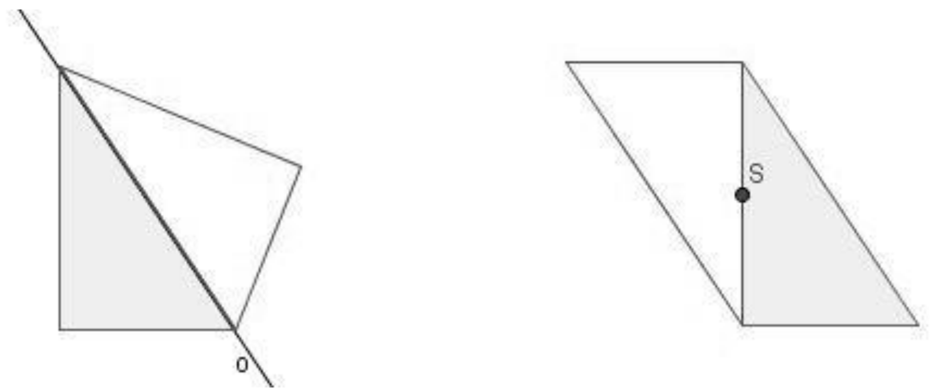

Fig. 1: Reflection of the right triangle in the axial and central symmetry

The left side of Fig. 1 shows the position of the axis of symmetry determined by the hypotenuse of the right triangle in which the right triangle and its image form the kite. The right side of Fig. 1 shows the location of centre of symmetry in the middle of the leg. The right triangle and its image form a parallelogram. Changing the position of the line of symmetry and the centre of symmetry enables students also get isosceles triangles and a rectangle. Students could write results of the investigation into a table with the position of the axis or centre of symmetry and the type of the quadrilateral. This activity could be the introduction into the investigation of specific types of symmetrical quadrilaterals.

Creation of multiple center-symmetrical geometric figures is the purpose of the activity which requires the composition of five identical squares to symmetrical figures.

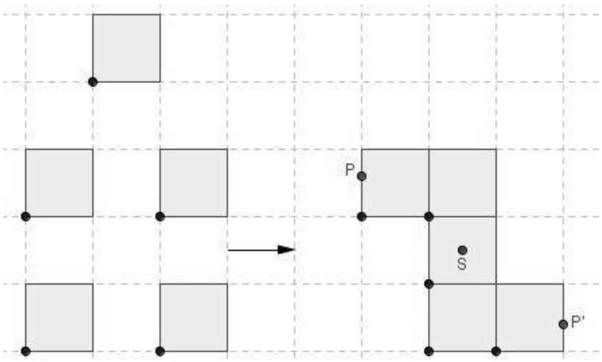

Fig. 2: Creating a centrally symmetrical image

On the left side of Fig. 2 are five squares constructed with, which is easy to move using the highlighted vertices. The students' task is using all the squares to set together centrally symmetrical shape. On the right side of Fig. 2, one possibility to create a centrally symmetrical shape of those squares is displayed. Students can construct the expected center of symmetry in a figure. Using a selected point on the square and its image they can test the symmetry of the composed shape. In the activity, students have the opportunity to create several types of a centrally symmetric figures.

The third activity can be used for modelling of the linear dependence. We have chosen an example to exploring the relation between the height of water column and volume of water for the uniform filling of the cylinder with water (see Fig. 3). Students can use the first slider (water) to simulate the flow of water into the cylinder. The height of water column in relation of the water volume in the cylinder is displayed in the coordinate system at the same time. Students should predict the type of dependence before the simulation.

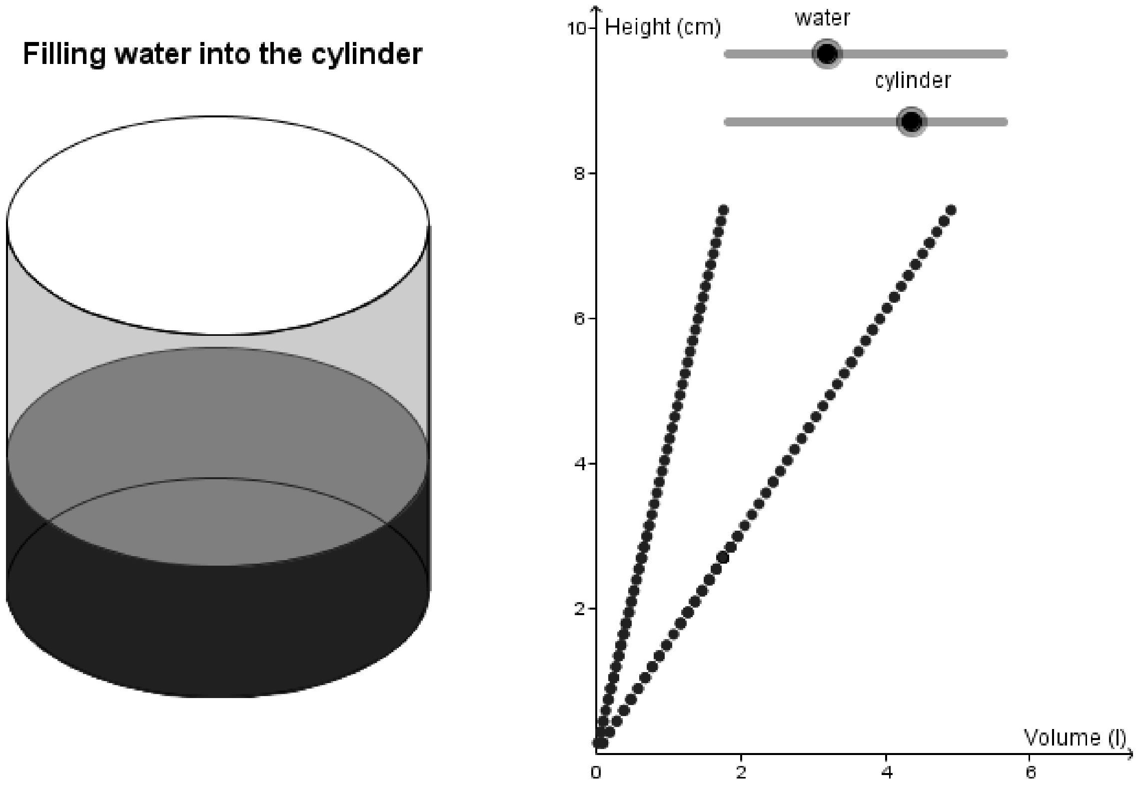

Fig. 3: Simulation of filling the cylinder with water

Then students may change the diameter of the base of the cylinder using the second slider (cylinder). Students can thus observe how change of the diameter of the base will affect the graphic representation of this dependence. Similar interactive demonstrations are available at http://demonstrations.wolfram.com/FillingAContainerDefinedByACurve/. Demonstrations also offer more complicated shapes of containers.

Studies to determine the status of the use of ICT in mathematics education

Application of innovative trends in mathematics education is often associated with the integration of ICT in the learning process. National Council of Teachers of Mathematics (NCTM) in the United States published the basic principles and standards for modern teaching mathematics in 2000 (NCTM, 2000). This document identifies six basic pillars of modern mathematics education. The integration of ICT in teaching mathematics to encourage active work with information and facilitate the learning was included among the basic pillars. Efforts to integrate ICT in education are clearly show also in the United Kingdom. The UK Government's Department for Education and Skills (DFES) was established in this country. The important aim of DFES is to characterize the potential for integration of ICT into the school curriculum subjects. The set of documents named ICT across the curriculum was created for the goal to present ICT in mathematics education.

Many studies and reports focused on the characterization of the potential of ICT in mathematics education were developed for DFES. Report for the project ImpaCT2 (Cox et al., 2004) states that 67 % of primary school students never or rarely used ICT in mathematics. It was more than 80 % of students in secondary school. The description of the situation in the USA in 2000 was one of the conclusions of the survey (Cox et al., 2004). One conclusion is that students used the computer in mathematics teaching occasionally, and only a small proportion of work with ICT was used productively. Goos mentioned in the document (Cox et al., 2003) about the results of a three year project in Australia. Research team came to the conclusion that ICT is most frequently used to enhance traditional approaches to teaching.

The situation did not change significantly over the next few years. The report of agency OfSTED (The Office for Standards in Education) (NCETM, 2010) states that the majority of students have only a little opportunities to use ICT for active work with the information in mathematics. The same document shows a graph (see Fig. 4), which characterizes the rate of the use of ICT in mathematics teaching at primary and secondary schools in the UK. The survey covered 1,990 primary schools and 2,061 secondary schools. The sum of percent in the chart does not 100 due to missing answers in some questionnaires and rounding numbers.

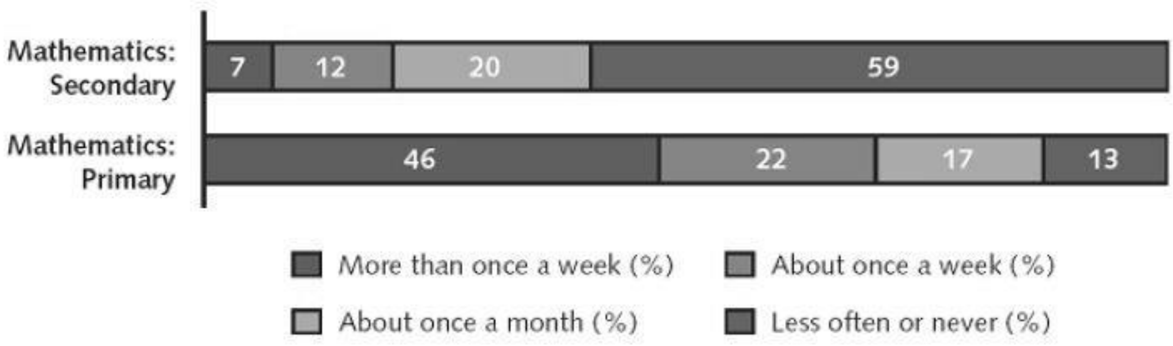

Fig. 4: The use of ICT in mathematics education (Keating, 2009)

Let us look at utilization rate of ICT in the teaching to our neighbours. In 2008 and 2010 Stehlíková and Špačková conducted surveys in the Czech Republic, which were focused on the utilization rate of e-learning at Czech secondary schools. The authors present that 48 % of secondary schools not used e-learning in 2008, when as the percentage decreased to 37 % of secondary schools in 2010. In 2008, e-learning was not use at secondary schools mainly because of lack of money to buy the software technologies. In 2010, inadequate technology equipment of schools was the main reason for non-use e-learning. We present a graph (see Fig. 5) from the paper (Stehlíková, Špačková, 2011) to compare other factors affecting the non-use of e-learning at Czech secondary schools.

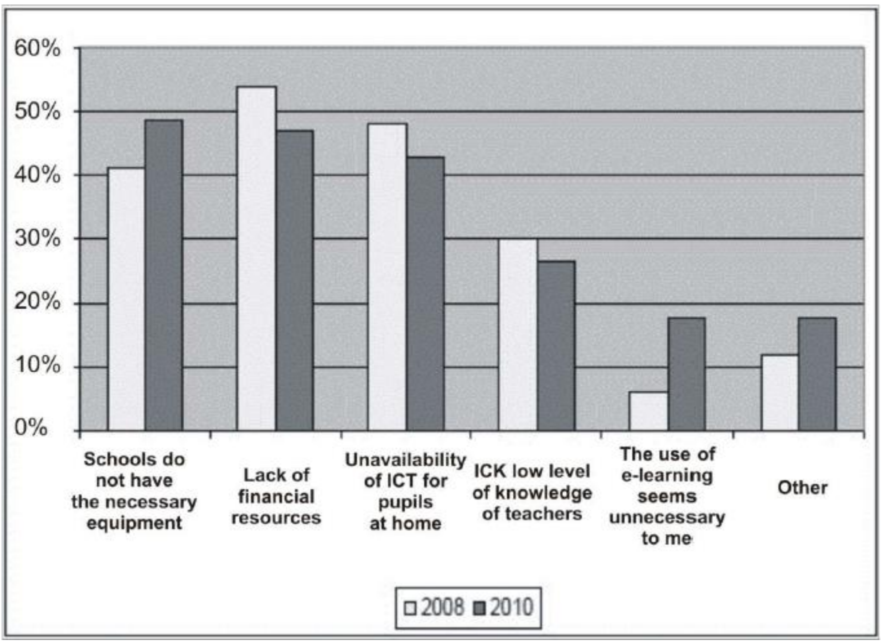

Fig. 5: The reasons for non-use of e-learning in secondary schools in ČR (Stehlíková, Špačková, 2011)

The efforts for innovation of the mathematics education with the support of ICT have been reflected in a variety of national and international projects. ICT can be used in the educational process in different ways. Teachers can include a presentation into teaching to supplement their explanation. However ICT provides a great potential to create the stimulating learning environment in which students can experiment, model, and discover new relationships.

International Project SITES (Second International Technology in Education Study) (Ainley et al., 2010) tried to bring more information for analyzing impact of ICT on teaching and learning and to create the more detailed view of the use of ICT in mathematics. The comparative research program SITES was launched in 2006 in 22 countries, among which was included also Slovakia. Great attention was paid to teaching mathematics and science in the 8th grade of primary schools. Norway was ranked in the first place of the participating countries who have declared the use of ICT in mathematics teaching in the 8th grade of primary school (80,29 % of teachers). Slovakia took the 11th place (51,17 % of teachers) in the list of participating countries.

Teachers should comment in the questionnaires also to the purpose and ways of the use of ICT. If we focus only on the use of ICT in teaching and learning, then teachers most used ICT to find information, to use of the educational resources available on the Internet (57,1 %) and to present information (51 %). The most mathematics teachers in Slovakia have claimed the use of additional devices such as projector and different types of calculators (48 %). Only 2 % of math teachers declared the use of modelling software.

Stols G. and J. Kriek in their survey (Kriek, Stols, 2011) devoted on analysis of the reasons why mathematics teachers do not use DGS. The survey was realized through questionnaires for mathematics teachers in South Africa in 2011. The positive, statistically significant correlation (0,754) was found between perceived confidence in their abilities and the digital literacy of teachers. The highly significant correlation (0,902) was observed between the teacher's perceived usefulness of DGS and the rate of the use of DGS in mathematics teaching. The important conclusion of the survey pointed to the finding that teacher will use DGS in the teaching process regularly only if he is satisfied that it will be useful for him and for students.

The survey to the use of DGS in mathematics teaching

The aim of the survey was to determine the status of the use of DGS in mathematics teaching at secondary and elementary schools. We are also interested in the evaluation of the teachers' opinions about the possibilities of the use of DGS to support the learning and in teachers' views on the benefits and effects of DGS for improving the teaching and learning. When we planned a survey, we focused on the following research questions:

- What is the rate of the use of DGS in mathematics teaching at elementary and secondary schools?
- Where teachers have acquired the skills of using DGS?
- How do teachers perceive and assess the benefits of DGS for teaching purposes and enhancing the quality of teaching?
- At what stage of the learning process do teachers use most frequently DGS and how do they organize learning?

The survey was conducted through distribution of the electronic questionnaire in December 2014. After the closure of the questionnaire, 48 completed questionnaires were recorded. One questionnaire was filled by the university teacher and therefore we did not include it in the final evaluation. The summary of responses to the questionnaire items is available at: https://docs.google.com/forms/d/1RkQTGeTCmpWweiPkjDFTQ5i1Hc-c9Xb4znJ2sxNuR3c/viewanalytics.

In January 2015, we distributed to teachers in the course of innovative education the same questionnaire in printed form. We have included in the final assessment 60 from the 61 questionnaires. The questionnaire was completed by 24 elementary school mathematics teachers (second stage) and by 36 secondary school mathematics teachers (grammar school, vocational schools). The questionnaires showed that 12 primary school teachers (50%) and 23 secondary school teachers (63,9%) use DGS in mathematics teaching of 60 participating teachers.

The information about other approbation subject that teachers have studied may be interesting for the evaluation of utilization rate of the DGS by teachers. Graph in Fig. 6 shows this information about teachers using DGS in the classroom that are divided by length of their teaching praxis.

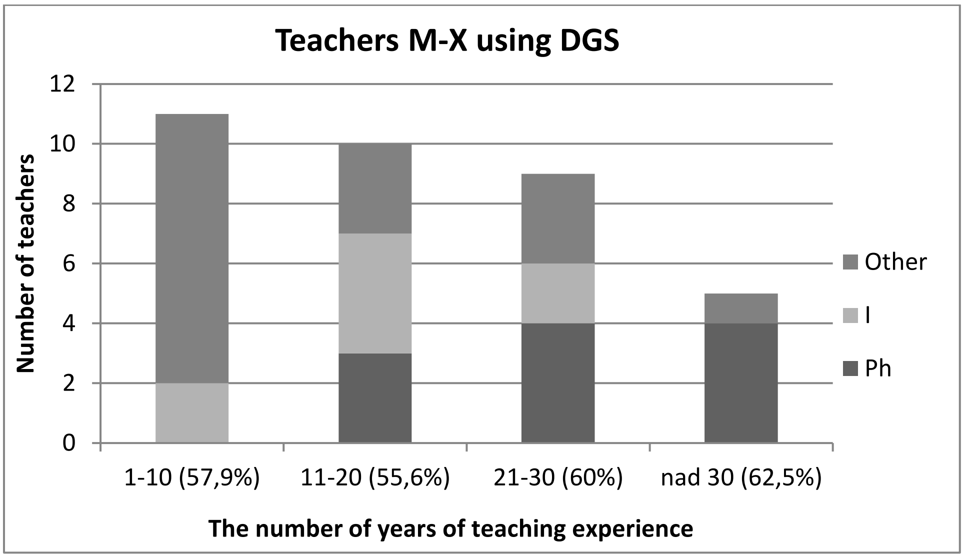

Fig. 6: The rate of the use of DGS by mathematics teachers

Between teachers with teaching experience more than 10 years the significant group consists of teachers that have studied physics or informatics with mathematics. Teachers with teaching experience over 30 years could not study informatics as a second subject of approbation. Teachers with teaching experience less than 10 years had a richer offer to select another subject. The graph in Fig. 6 shows that the most teachers using DGS has teaching experience less than 10 years. However, the situation is different considering the number of teachers in each category. The percentage of teachers using DGS is shown in the graph in Fig. 6 in brackets after the number of years of teaching experience. The survey sample of teachers shows that the length of teaching experience has not significant impact on the use of DGS in mathematics teaching.

The vast majority of teachers using DGS (77%) indicated that they use the system GeoGebra. Since the item of acquiring the basics of working with DGS had the open form, not all teachers using DGS wrote down the answer. The most teachers reported various forms of further education (16) and self-study (8).

The views of teachers on the benefits of DGS for facilitating learning and increase the quality of teaching were divided into five-point scales. The most positive views were assigned to the value 1. The graph in Fig. 7 shows the positive views of teachers divided into two groups by the use of the DGS in mathematics education. Opinions of teachers that do not use DGS are not based on their own experience, but they are derived from their knowledge about the tools and functionality of DGS.

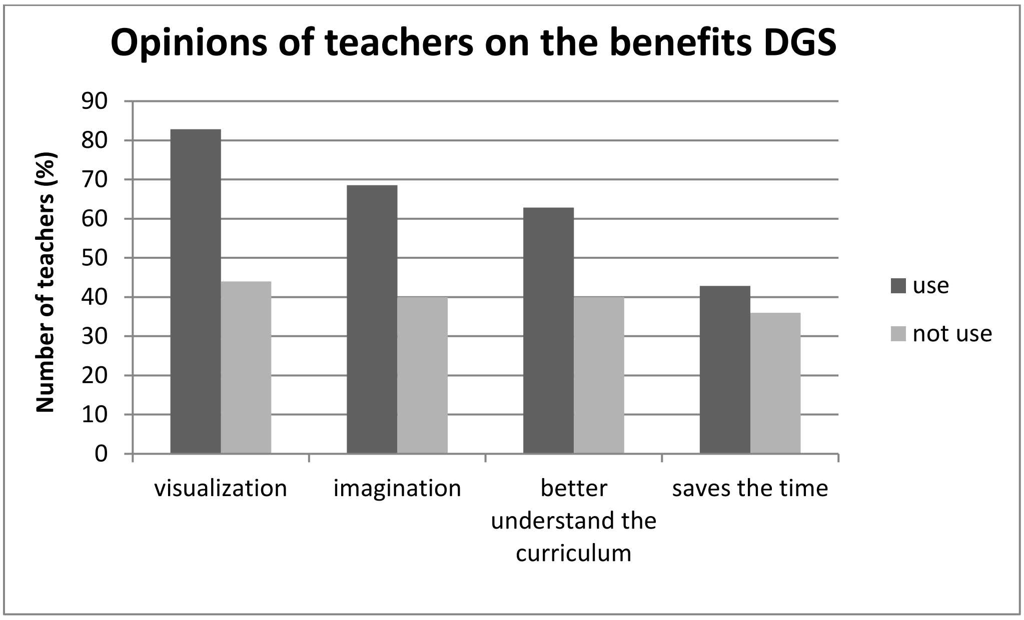

Fig. 7: The teachers' opinions on the effects of DGSin mathematics teaching

The evaluation of respondents sample showed that teachers using DGS in education have greater conviction about the appropriateness and benefits of the use of DGS for teaching purposes. The most teachers (34) reported that they use DGS in the teaching of geometry. Then follow: function (24), equations, inequalities and their systems (8).

The graph in Fig. 8 shows stages of the learning process in which teachers most frequently use DGS and how they organize learning. We evaluated 34 responses because one of the teachers using DGS did not answer. Teachers use the most frequently DGS in the explaining the new curriculum. In terms of organizing learning is represented demonstration, individual and group work nearly as well.

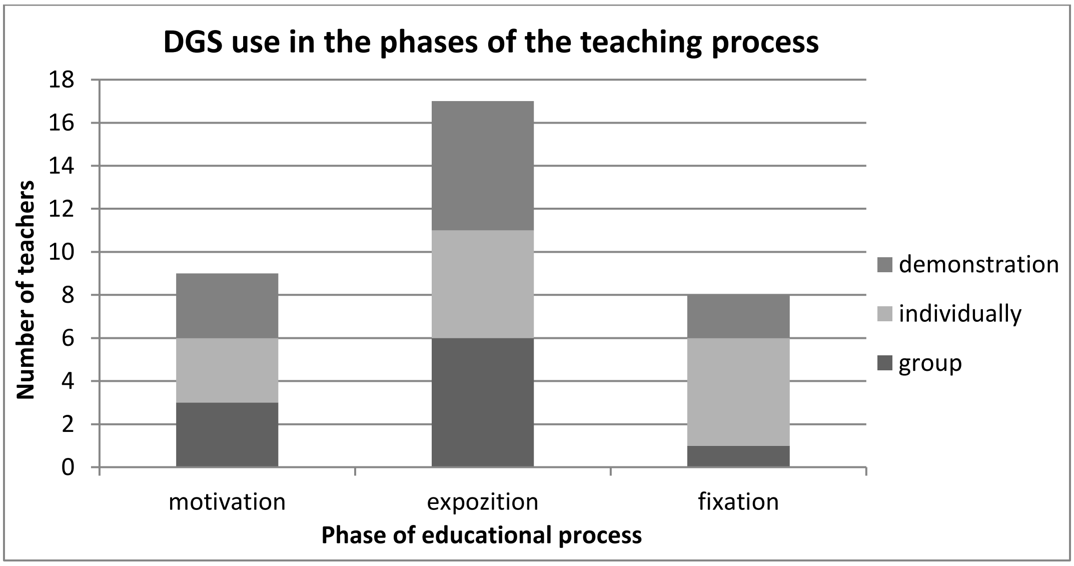

Fig. 8: The teachers' opinions on the use of DGS in the teaching process

The most teachers (12) mentioned as a reason for non-use DGS a lot of the time needed to learn the program by the students. Seven teachers reported about their insufficient working skills of the use of DGS. Teachers reported the following additional weaknesses of the use of DGS in the mathematics teaching:

- the time required for preparation of teaching plan and teaching materials,
- a large number of students in the classroom,
- concern about the weakening of traditional skills of students,
- the benefit from the use of DGS is not adequate to time spent in teaching process.

Interviews with the teachers

We have made interviews with teachers as a complement to a survey we conducted means of a questionnaire. The interviews were conducted in September 2015. We talked with three secondary school teachers from three grammar schools. Two teachers were from Kosice and one was from Presov. The first teacher (marked with A) uses DGS in the mathematics teaching for more than 10 years. The second teacher (marked with B) uses DGS in the mathematics teaching approximately six years. Finally, the third teacher (marked with C) using DGS in the mathematics teaching only the first year.

Two teachers are involved in the project APVV in which are drawn lessons plans and interactive activities where they use GeoGebra in the teaching a plane geometry and the functions.

The interview had uniform structure and it is consisted of four parts. The first part was devoted to DGS and to the conditions for its use in schools. The second part was focused on a preparing of teachers to teaching with using DGS. The third section was about the teaching process. Finally, in the fourth part, we asked the teachers to evaluate the impact of DGS on teaching outcomes and understanding of mathematical educational content.

In the first part of the interview, all three teachers consistently say, that they use the software GeoGebra. Teacher **A** said: *“In the beginning I used the Cabri and later I switched to GeoGebra, because it seems to me that GeoGebra is better because provides a connection between geometry and algebra. GeoGebra is accessible and yet free.”* Regarding the technical equipment of schools, there are also teachers responded similarly. They noted that the schools have a computer rooms, but do not have enough computers to ensure that every student works alone. They also do not have access to computer labs still when they need it. Although GeoGebra is also available on the mobile platform, schools do not have a sufficient number of tablets for classroom teaching.
On the question how they have acquired a working with DGS, we got different answers:

A: *“I learned a majority in a course for teachers.”*

B: *“I am a completely self-taught in a control of GeoGebra.”*

C: *“For the most part I'm a self-taught, but a colleague at the university also helped me.”*

The second part of the interview was focused on the preparation of teachers on teaching. We asked, where teachers obtain teaching materials from, respectively, ideas for teaching.

Experience of the teacher **A** will be demonstrated in this section. The teacher A said: *"I mostly used my own materials which I have used before in the some interpretation or discovery. I just created them by GeoGebra."* Teachers **B** a **C** answered similarly that they look for ideas on various internet portals (*http://mathworld.wolfram.com/*, http://www.realisticky.cz/) and then they edit them using GeoGebra. The teacher **B** explained the reasons for this procedure: *"GeoGebra is more convenient for processing and more comfortable for students."*

Then teachers evaluated the time devoted to preparing lessons with using DGS and appropriate teaching materials. Teachers **B** and **C** have said consistently that their preparation takes approximately as much time as a preparation on traditional lessons. Teacher **A** has a different experience: *"The preparation takes me a lot of time. Producing some applets can take me up to 6 hours, as they are quite complex and useful at different stages of the learning process. One applet can be used to discover and also even at practicing. From my perspective, definitely worth the sacrifice a time to prepare teaching materials. Students appreciate it."* This teacher try to create a more complex applets containing a more complex interactive elements and questions for students and therefore the preparation on the teaching takes more time.

The next part of the interview was focused on the course of mathematical lessons using the DGS. Teacher C, which has a less experience, said that it she used GeoGebra only for motivation and exposition of the new educational content. Teacher **A** and **B**, that have more experience answered the same way that they work with GeoGebra throughout the lesson and at all stages of the learning process, except for diagnostic. All three teachers work with GeoGebra on lessons just frontally. Thus, teacher or the selected student works on a computer and a projector displays images for the students. The teachers try to use a problem explanation and questioning. Teachers ask from students to formulate hypotheses and conclusions. Teacher **B** has an interesting experience that she tried to use GeoGebra also for independent work of students: *"When the students work with GeoGebra, so it is very slow and it takes a lot of time out of lessons."* Teacher **B** stated as a reason that students have a different skills of exploitation of GeoGebra and some students are not interested in exploration and problem solving.

Experience of the teacher **A** focused on topics in which she use DGS is as follows: *"I use GeoGebra for teaching functions and also for the solving construction problems. Very good is the use of DGS in the geometric constructions on the same view. I think it's very useful. Also, it's great in the differential calculus."*

Teacher **B** said that she uses GeoGebra in teaching geometry and also by the constructing graphs of functions. And the teacher **C** uses DGS only in the geometry.

During the interview we will not avoid the topic of geometric constructions. It also shows the difference in the experience of the teachers. Teacher **A** expressed the opinion that, DGS is unnecessary in solving simple geometric constructions. On the other hand, teacher **C** is convinced that the GeoGebra is also very helpful for solving the construction tasks. Teacher **B** sees the benefit of GeoGebra for solving the construction tasks especially in the discussion about number of solutions.

The last part of the interview was focused on overall assessment of the benefits and limitations of the use of DGS in mathematics teaching. We were interested in the opinion of teachers about the use of DGS from students' views. The final evaluation of the teachers looked like this:

A: *"This generation of students is so fast that they have no problem in coping with the program GeoGebra. Many students obtain the necessary imagination when handling with applets. Then students will better understand the educational content. The use of DGS can certainly facilitate the work of the teacher."*

B: *"DGS are suitable for students who have problems with an imagination. Because they can have good analytical thinking, can be perfectly in algebra, but they have difficulties with the solution of geometric problems and DGS can help them. I believe that the possibility to change the parameters in the constructions is a great benefit for the students.*

C: *"I see the greatest benefit of the use of DGS in mathematics teaching in improving imagination and conceptual understanding. Of course lessons by using DGS are more diverse and therefore the atmosphere is more creative."*

Finally, the teachers were asked to comment whether the use of DGS in mathematics teaching increases the motivation, respectively, improves the attitude of students towards mathematics.

A: *"The students appreciate teaching with GeoGebra. When not used for some time GeoGebra in the teaching, so students are already asking when we will work with GeoGebra."*

B: *"The motivation is elevated, some students work with GeoGebra at home and they are interested in mathematics."*

C: *"I think so yes, but students can lose interest, if the teaching with the use of GeoGebra is getting too stereotyped. Although, it may be motivating mainly at the start of selected mathematical topics."*

Our interviews with teachers indicate that teachers use GeoGebra especially for the frontal teaching. As the main reasons for this form of using GeoGebra they had given insufficient technical equipment of schools, students' different skills and to save the time. GeoGebra functionality on mobile platform could help to remove the first hurdle. Our knowledge from the survey shows that teachers do not yet have experience of using GeoGebra on tablets. If students should use GeoGebra also to solve some homework, they would gain skills that could be used also in mathematics classes. At present on Slovak secondary schools, teachers can divide one lesson of mathematics a week. Divided lessons give a more space for independent work of students and for the use of ICT.

Conclusion

In respect of small sample of mathematics teachers at the elementary and secondary schools we cannot make general conclusions about the use of DGS in the mathematics teaching. We were unable to obtain information from the teachers, whether they use DGS also for create a stimulating learning environment which could enable students to experiment, explore and discover the properties of objects and mathematical patterns. Similarly to other studies (Kriek, Stols, 2011) our survey showed that enthusiasm and internal conviction of teachers are crucial to integrate DGS into the mathematics teaching. We have found during interviews with teachers, how teaching materials they are used and how much time teachers spend on preparing teaching with using GeoGebra. We managed to get the detailed information about the course of lessons of mathematics teaching with the help of DGS. Teachers believe that students appreciate their work. Based on the interviews, we realized we can say that the experience and years of work experience with the use of DGS in mathematics teaching, affect the quality and processing of teaching materials and methods used in teaching with support from DGS.

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ADAPTIVE E-LEARNING: FROM THEORY TO PRACTICE

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Abstract

The theory of adaptive e-learning – the principles of which were published in a monograph (Kostolányová, 2012) – is being developed at the Pedagogical Faculty of the University of Ostrava. However, the verification of the theory in pedagogical practice required much further work, both research and routine. This paper presents the results of several years' work of researchers, particularly the development of the adaptive LMS, the proposition and implementation of an expert system for the management of the Virtual Teacher, realized pedagogical experiments concerning the system and further development of the theory.

Keywords

adaptive education, individualized education, adaptive LMS

Theory of adaptive e-learning

By adaptation of education, we mean the changes in the teaching of the same curriculum that are carried out in a different manner to suit the needs of every student. As far as full-time study in a classroom is concerned, the consistent individualization of education is virtually impossible, particularly due to time constraints. Not even an experienced teacher who is able to adapt the instruction to the needs of every student can afford to use this method. The ideal way is to use the e-learning methods, i.e. ICT tools, as long as we do not use the Internet solely for the presentation of study materials and multimedia, but we "teach" it to adapt education – to automatically individualize it according to what kind of student it is teaching.

The presented scheme of automatic individualization helped solve a number of partial problems. The problems were published in (Šarmanová, Kostolányová, 2010) while the resulting theory of adaptive education (TAE) was published in (Kostolányová, 2012). And since it is an original theory and the following chapters are directly linked to it, we will introduce its basic principles.

Student and their individuality

In order for the program that manages individualized education to be able to manage it in an individualized manner, it needs to know a number of information about the student concerning their learning style (LS). A large number of theoretical pedagogues and psychologists deal with the LS theory. Those defined several characteristics – students' qualities – that influence LS. An extensive analysis helped define a tuple of mutually independent characteristics that determine the student's LS. They were published in (Kostolányová, Šarmanová, Takács, 2009). The following are the characteristics and the 14 values:

- Sensory preference of perception (verbal, visual, auditive, kinaesthetic) = 4 values
- Social aspect (the student prefers to learn on their own, in pair, in a group) = 1 value
- Affective aspects (motivation to study – inner, outer) = 1 value
- Learning tactics, including:
    - Orderliness (the student studies systematically sequentially or non-systematically randomly) = 1,
    - Way of processing information (theoretical derivation, experimenting) = 2,
    - Technique of processing information (detailed – from bottom to top, holistic – from top to bottom) = 2,
    - Approach to study (in-depth, strategic, surface) = 1,
- Degree of self-regulation, the ability to self-manage the study process = 1,
- Success rate, talent for a studied course = 1.

Each of the mentioned qualities is rated on a scale <0,100> or <-100,100> (for motivation, approach and self-regulation). The program obtains the initial values of students' qualities through a questionnaire. Because the values obtained in this way may not be absolutely accurate or may change over time, the program system contains an "adaptive loop" for LS. The loop analyzes the data that monitor every student's education process in detail, evaluates the agreement between the student's behavior and their current characteristics and adjusts the data according to reality (if need be).

Structuralization of study material

The second important element that influences the quality of education is a study material. We will not pay attention to the factual correctness and didactic quality of the material, which we – for the time being – leave to the author. Moreover, those qualities are dealt with in further research.

As far as adaptability is concerned, there is another question: What form does the study material need to have in order for it to be adaptable to every current student's LS?

One way, chosen by the majority of experts dealing with LS, is to create a different variant of the study material for every type of student (often named). As far as 2-3 qualities with two poles (does – does not have quality) are concerned, there is a reasonable amount of variants. However, as far as the greater number of characteristics is concerned, there would be an unbearable amount of variants (our 14 characteristics with only 2 values of every quality would have 2^{14} = 16,384 types).

We chose another way. The characteristics, which require the curriculum to be formulated in a different manner, will come in variants. It is 4 **sensory variants** (which require the use of various “active” words in text or different types of multimedia) and the success rate (which requires the instruction to have different levels of detail or extent). 3 levels of the so-called **depth of instruction** were chosen. Overall, there are 4x3=12 variants of instruction.

Other characteristics are being dealt with in a different manner. First of all, we use a classic division of the course curriculum into chapters or units. Gradually, the unit contains new information and new terms. We named the unit of such information (for instance 1 new term) a **frame**.

By analyzing in which the variants of study materials should differ with respect to different values of students’ other qualities we came to a conclusion that they differ mainly in sequence and the choice of particular parts within the frame. For instance, a theoretically equipped successful student would prefer the following sequence: theory, explanation, examples and examination; an unmotivated and less successful student will need motivational examples, more detailed explanation, theory, examination and motivational compliment. The “rules” for adaptation, i.e. how to choose and organize particular parts of the study material according to the student’s LS, can be formulated in a similar manner. Those considerations led to the division of every frame into parts, called **layers**. The following layers were defined: instructional (theoretical, semantic, fixation, solved examples and practical examples), test (theoretical questions, tasks and practical tasks) and special (motivational, navigational, formulation of goals, literature). The layers turned out to be in agreement with didactic principles, Gagné’s theory of the education process and other pedagogical-psychological principles.

The result of all the considerations is the division of the education process into units and frames; frames processed in sensory and depth variants with every variant being divided into layers.

Virtual teacher

We named the program, which manages individualized education, the Virtual Teacher (VT). The program is designed to create an optimal version of the study material from the author study material structured into frames, variants and layers for the current student defined by their LS characteristics. The entire process is divided into 2 phases.

In the first phase, the VT defines the so-called optimal learning style (OLS) of the current student. It means that it compiles a theoretically optimal selection and sequence of every frame’s layers valid for any study material. However, the actual study material does not have to contain all the variants and layers for every frame (see the end of Paragraph 1.2).

That is why there is the second phase of the VT, which is realized for every current frame one more time: based on the student’s OLS it defines the so-called actual learning style (ALS) where the frame adaptation is adjusted to a real frame. Possible missing variants or layers are replaced by the closest ones or omitted entirely.

Both phases are managed by a series of expert rules representing the author/teacher choice of the suitable variant. The form of the rules is very important. One possibility is to define the selection and sequence of layers rule (for phase 1) for every type of student, i.e. for their tuple of qualities. However, this would make the abovementioned problem of an enormous number of LS types an expert's concern instead of author's.

Therefore, a more general solution was proposed: instead of the "complex" rules the "elemental" rules were defined which react to every quality (or a pair of qualities) and its value (the degree of the quality) separately. There is a lower number of such rules, they are simple, easy to understand and easily formulated. The rules determine which variants should be selected and which layers and in which sequence should be presented to the student.

For the entire tuple of qualities and with the use of a proper algorithm, the VT then compiles the mentioned OLS out of a set of relevant rules. When creating the ALS, other rules determine when the missing variants or layers should be replaced or omitted entirely.

Expert rules materialize "pedagogic experience, knowledge and skills" in the management of individualized education. However, it cannot be expected that the currently defined expert rules will be optimal for all types of students. Moreover, different teachers will have different opinions concerning their formulation. Therefore, the system of rules is designed (and realized, see Paragraph 2.4) in a way so that it could be easily user modified or replaced without having to change a program. Every pedagogue – expert – can set and verify their own theory of the management of adaptive education. This possibility has already been used in pedagogical experiments (see Chapter 3).

Realization of adaptive education through adaptive LMS

The proposed detailed theory of adaptive education needed to be verified in practice. As there was no LMS which would be able to use the expert rules to create the optimal version of a study material for a particular LS from a detailed study material, it was necessary to create such LMS. In 2010-2012, students and teachers of VŠB-Technical University of Ostrava (Drápela, 2013; Takács, 2014) and the University of Ostrava collaborated on the development of such system, which was realized as the LMS Barborka 4 (versions 1-3 contained only partial solutions of adaptivity). The research was supported by two projects ESF OP VK. The system is still being developed; new functions and rules are being added.

LMS purpose and structure

This adaptive LMS is not primarily intended for collective education (it does not contain the needed functions of the Tutor module concerning tests, tasks, etc.) but it is used as a research tool by academic scholars and Ph.D. students at the Pedagogical Faculty of the University of Ostrava.

The entire LMS is divided into the following modules: Student (identification of students and a questionnaire for their initial characteristics + the instruction), Author (storing and modification of study materials), Expert (algorithms of the Virtual Teacher, an expert system for the rules of the VU, a system for the data analysis), Tutor (organization of education, submission of tasks, realization of tests, etc.), Admin (system administration). As far as adaptivity is concerned, the Student, Author and Expert modules are important.

Author module and creation of study materials

As has already been mentioned, it is the author who decides about the factual content of a study material. However, an adjustment of the study material to the requirements for the structuring of a workbook into frames, variants and layers requires the author to become acquainted with the TAV, the methodology of the processing of variants and the meaning of types of layers.

In order for the frames to be adaptable (so a different sequence of their layers could be used), the layers should be self-supporting. It means that the entire frame needs to provide quality instruction even when a different sequence of layers is used. For instance, the student-experimentalist prefers the following sequence: practical example, explanation and theory. On the other hand, the student-theoretician prefers theory to come first followed by explanation and practical examples.

As far as the sensory variants are concerned, the author needs to become acquainted with the recommended formulations for different sensory types of students. And because the author often belongs to one of the types, their language is influenced by that type. As a result, they need to learn to express the same sentences in a different language for different sensory variants. For instance, for the auditive student the author should use “auditive” words such as “let’s listen to”, “let’s discuss”, “the sentence goes…”, etc., for the visual student “visual” words such as “we can see that…”, “let me show you…”, “varied”, etc. The author should follow the similar pattern when addressing the other sensory types.

As far as the depth of the instruction is concerned, the author needs to imagine they are instructing the average student. To this, the author needs to add something for the above-average student so they do not become bored and for the slower student they need to make the instruction more detailed and adjust its pace.

The storing and modification of the finished study material in the LMS can be done for every individual layer separately. In order for the VT system to be able to distinguish between the many variants and “know” which layers belongs to which variant and frame, parts of the study material need to contain the so-called metadata in which the system information about the structure of the study material is stored. That is another difficult task for the author.

The author usually does not create the study material in the LMS but in the text editor, multimedia are created with the use of various SW tools and the author makes notes about their placement in the text. The author saves the unit or the course to the LMS only after it has been completed. In order for the author not to lose track of the entire structure, a “form” in MS Word was designed with pre-filled boxes for metadata and containing the entire structure of the frame. As a result, the author can comfortably structure their text and does not lose track of variants and layers. The author either uses the pre-filled metadata or makes a note (usually with only one symbol) in the form. The author (or an assistant) then saves the finished study material with metadata in the LMS.

We must stress that the author does not have to deal with when a particular variant, selection or the sequence of layers is used during the actual education process. In contrast to programmed education (which is still frequently used in adaptive systems), The VT deals with this issue. The "programming" of the education process is automated not only for the average student but also according to the student's LS.

Student module and instruction

The Student module is use friendly. After the first log-in the student is asked to fill out a questionnaire from which the initial characteristics for their LS are determined. The questionnaire was compiled by a psychologist (Novotný, 2010).

Afterwards, the student chooses the course and unit after which they are being presented with a series of frames in the sequence of layers adapted by the VT according to their LS. The student (as it is usual in e-learning) chooses their own pace of education. However, the student does not have to follow the variants and the sequence of layers offered to them by the VT. At any time the student can choose another existing neighboring variant of instruction (of another sense or depth) or move on to another frame in the unit.

Test layers, theoretical questions and tasks included in the frames constitute the smallest "adaptive loop" of the entire education process. When the student answers incorrectly they are provided with a four-stage help, which should help them always come to the correct answer. This is the way the continuous control of the students' understanding of the partial paragraphs' (frames) content works.

Besides the instructional units, the author can also use tests containing only test layers, which are usually placed in between the units. The author or the guarantor of the course decides about the number of tests (usually there are several mid-term tests and one final test). The tests constitute the middle "adaptive loop" of the entire education process, which controls the students' understanding and learning of the larger wholes of the course.

Besides the actual instruction, which is carried out in the described manner and managed by the VT, the student can also choose from 3 other modes: usually the introductory mode 1 guides the student through the unit presenting them only with instructional layers, without continuous examination. This is usually followed by mode 2.

Mode 3, which displays only test layers, is intended for final revision. If the student answers correctly, they can proceed to the following question. If, however, the student answers incorrectly, they can use the abovementioned help that refers to the particular instructional layer or the entire solution which is described in the so-called HELP layer.

Mode 4, which is intended for self-testing, contains the final test. The student answers the questions and solves the tasks as in a real test, i.e. without any help and within the specified time limit. At the end of the test the student receives the result. The student can take the self-test any number of times until they are sufficiently prepared for the real exam.

The last two modes are designed and discussed in the dissertation (Prextová, 2014).

The student's every "mouse click" in every mode is recorded in the education process protocol. The analysis of the protocol can reveal interesting facts about the student, the study material or the rules for the management of instruction (see Paragraph 2.6).

Virtual teacher: expert management

The Expert module is the main research tool of adaptive education. Besides the functions of the management of education itself, it also has other functions.

The Expert module unique expert system with the database of expert rules and algorithms for their use represents a brand new approach to the management of education (Takács, 2014).

According to the TAV theoretical proposition, the database contains expert pedagogical-psychological rules used to create the OLS and ALS of the current student.

The database of rules is structured into several groups according to the educational content: generally valid – basic pedagogical principles; for a group of courses – e.g. field of study, subject; for a group of frames – e.g. unit, particular frame; for a group of students – e.g. classroom; for a particular student. Another way of the division of rules is according to the mode of education – first reading, instruction, revision, self-testing.

Moreover, the author can also select only some of the rules and set their own rules in any group's frame. They can do so by using the LMS without having to consult the programmer. This enables researches from the field of adaptive education to set their own rules and conduct their own experiments when verifying the optimal procedure for different types of students and courses.

The rules are of the IF – THEN type, presumptions are the characteristics of the student's LS, consequences represent the choice of sensory variant of the frame and recommended selection of depth and the sequence of layers. As has already been mentioned, the rules are elemental and contain only 1-2 characteristics in the presumption. That is why it is necessary to choose all the relevant rules coinciding in presumptions with the LS characteristics when creating the OLS. The specially designed OLS inference algorithm, which compiles the sequence of the recommended steps (frames) of the OLS, is used on selected rules. The step is described as follows:

(layer_type, layer_sequence, layer_depth.)

The ALS algorithm modifies (if need be) the OLS sequence according to the offered layers of the current frame. If any of the theoretically defined layers does not exist because the author did not include it, the algorithm tries to find the closest layer or omits it entirely. This algorithm is also controlled by expert rules.

The setting of the rules for education has already been used in the dissertation (see Chapter 3).

Modeling of virtual teacher's expert decision making

It was necessary to verify the realized expert VT system, particularly the correctness of the formulation of rules and the realization of inference algorithms for both the OLS and ALS. The verification had two phases: (1) OLS for every type of student needed to be created (as has been mentioned above, there is a large number of such theoretical techniques); it needed to be verified that the created sequence of layers follows the expert's concept; (2) ALS for every type of student including every possibility of missing author layers needed to be created; it needed to be verified that the created sequence of layers follows the expert's concept.

There are two reasons why all the verifications could not take place in the actual instruction. Firstly, there are thousands of student types, which makes it impossible to find all of the theoretically defined types for the experiments. Moreover, every type should be verified on more than one person. Secondly, it is impossible to create an adaptable course in all possible variants of missing layers as there are dozens of combinations.

As a result, a tool for debugging of rules and algorithms of the VT (Kostolányová, 2013) was proposed, realized and integrated in the Expert in the LMS 4 Barborka, which made it available to other researchers.

The tool for modeling of the expert rules and algorithms of the Virtual Teacher makes it possible to include the support model – a fictitious study material that marks the layers included in the material, and to set a tuple of characteristics of a fictitious student. The support can be easily set through a graph that visualizes its structure while the student characteristics are entered into a simple form.

After the mentioned information has been entered, the system performs a complete calculation for adaptive education, i.e. the calculation of the OLS and ALS sequences. The set expert rules and both VT algorithms will be used. The result is visualized into a proposed graph which contains all sensory and depth variants with all types of layers. Different senses are displayed in different colors while the layers are vertically divided into the following groups: introductory, instructional, test and literature.

The calculated sequence of the ALS is not represented by trios; instead, in the pattern, every trio is represented by a black dot in the selected layer and variant. The dots are connected by line segments so the entire sequence has a form of a transparent graph. As a result, the expert can easily verify whether or not the calculated ALS coincides with how they think the instruction should be adapted. When only some of the students' qualities are entered and the instruction is comprised of more resulting ALSs, they are all displayed in one graph. This way it is possible to debug several LS types at the same time and verify whether or not the study material is consistent in key parameters.

The presented tool was used for debugging of all basic generally accepted rules and both algorithms. It led to discovering and correcting of several errors both in the rules and in the inference algorithms. The current version of the VT conforms to the requirements of the experts who designed the rules.

Course of instruction protocol analysis

It has already been mentioned that the entire education process of every student is being recorded: every mouse click, every move to the next layer, every time the student deviates from the recommended educational sequence, the student's every answer, etc. Extensive data are gathered which, when analyzed, may provide feedback on the education process. The instruction analysis has three main parts.

The first analysis is the effectiveness of instruction from the point of view of the correctness of author study materials (Dvořáčková, Šarmanová, 2011). It is evaluation of the course study material based on the monitoring of a number of actually completed educational processes. Not only opinions and feelings of students from the evaluation questionnaire are being analyzed, but also their real behavior during the education process. The analyses assume that the characteristics of all students are correctly set and the educational rules are correctly formulated. It is aimed at specifying the parts of the study material that are either unsuccessful in general, or for particular types of students.

The second type of analysis assumes the already debugged study materials and examines the correctness of the adaptation of the study material for particular students. In other words, it verifies the correctness of the currently registered student characteristics. If the student often chooses other than the recommended variants, it means that they are not satisfied with the preset ones and that the error may be in the incorrectly set "commands" of the VT, i.e. in the incorrectly registered characteristics. If the same behavior of the student occurs in more than one course, the system can automatically modify their characteristics and further monitor their behavior during the instruction. The student's characteristics can change with their LS gradually changing. When some of the student's characteristics are incorrect (e.g. surface approach), such changes are appropriate and the VT rules should lead to them. Such analyses are being conducted.

The third type of analysis examines the correctness of the preset expert rules of the VT. These are the most demanding analyses, which are also currently being developed. They should result in the debugging of all study materials and the correctly set current qualities of students. Afterwards, it needs to be determined when the majority of students are not satisfied with which rules or when the rules do not lead to the improvement of students' LS.

Further research concerning theory of adaptive education

The TAV published in 2012 contained the defined basic principles of the adaptation of study materials depending on the LS of particular students. A number of other pedagogical-psychological and implementation problems concerning the theory were defined during the realization of the principles in the LMS, their verification, pedagogical experiments and theoretical discussions of the entire group of researchers. We will present the ones that have already been solved.

Adaptive testing theory

The theory of adaptive testing was a natural extension of the theory of adaptive education. The basic education mode contains test layers of three types: theoretical questions, application tasks and practical tasks. They are used as immediate feedback and are used particularly for the student as they help them determine whether or not they have mastered particular parts of the studied curriculum.

We know from pedagogical experience that the long-term memorization of the acquired knowledge is even more important than the immediate knowledge. Separate tests during the course of instruction (covering larger units of the curriculum) or at the end of the course are used for this purpose. The students should have a tool at their disposal that would help them verify their knowledge before the actual examination. Besides the possible sensory variant of the formulation of questions, there should also be a tool that would offer the students the possibility of both self-testing and the immediate help when they are having trouble with the curriculum.

This issue is being dealt with in (Prextová, 2014). The theory of adaptive testing has been formulated and two other modes of education have been proposed: repetition with consultation and self-testing.

Adaptive testing consists in the adaptive presentation of questions and tasks of different difficulty levels to the student. When the student answers correctly, they are presented with more difficult tasks. All tasks are of the minimal recommended level of knowledge. The tasks (theoretical and application) are organized into a "matrix", vertically according to several levels of difficulty, horizontally browsing through the curriculum of the tested course.

The student deals (horizontally) with all tasks of a unit or a course. Every student works on a particular level which is determined according to their reactions. At the end of the test, it is determined at which level the student answered the most questions, i.e. at which level of knowledge (and a grade) they currently are.

When the student answers incorrectly, they are offered the mentioned 4-stage help. The first time the student answers incorrectly, they are only notified about the incorrectness of their answer in order for them to be able to correct any possible typing errors or slight incomprehension. The second time the student answers incorrectly, they are offered simple help. The third time the student answers incorrectly, they are pointed to the exact part of the study material so they can once more go through the particular section related to the tested theory or the solved tasks. If the student still answers incorrectly, the complete solving process is displayed to them, which they then only copy.

The so-called equivalent questions are another way of expanding adaptive education and the testing process. In order to prevent the student from being presented with the same questions during their way through the course in the repetition and self-testing modes, the author can enter a group of questions instead of only one question (in the metadata, such questions are in a group). This way, if the student answers any of the questions correctly at the first try, the next time they go through the course they are not offered the same question but one of the equivalent questions. The equivalent questions differ in the formulation of facts, numerical values in mathematics or physics, the use of different sentences to test the same grammar in languages, etc.

Therefore, there are individual records of every student's LS characteristics, but also of the entire course of instruction: which units, frames and layers they have gone through, at which of the testing layers they were successful, how many times, etc.

Foreign language instruction theory

Compared to other subjects, the instruction of foreign languages is specific. It is not based only on teaching the student, through any sense, knowledge and skills from the syllabus of the subject, but on teaching them to use all the senses in a foreign language equally well: auditive for the understanding of listening, visual for reading and writing, kinaesthetic for practice speaking, verbal for vocabulary and grammar rules.

(Horký, 2014) focuses on one of the theories. The development of skills is the basis of the instruction of foreign languages – listening, speaking, reading – and also the grammar and vocabulary. The development of language skills and knowledge requires the so-called stretching of styles, i.e. to learn how to use the subordinate styles. This theory is based on the assumption that superiority and inferiority of sensory styles could reflect the sequence and depth of the assigned study materials.

The study material makes the student go through all sensory variants, but in a different order. The student starts with the variant of their strongest sense, continues with the second strongest and ends with the weakest sense. The basic principle of this method lies in the fact that the information acquired in previous steps makes each further step easier for the student.

Since at the time of the experiment the expert rules did not contain rules for the change of the sequence of frames, they needed to be added. That marked the first time the new rules were used in a special research.

Instruction supported by semantic network

Another way of improving the possibilities of the LMS is supporting the instruction by the semantic network. The semantic network is a graph of the nodes-edges type where the node represents the term and the edge in between the nodes represents the relations between the terms. In reality, there are various types of relations between terms.

The semantic network (SNT) in the LMS 4 Barborka (Šeptáková, Šarmanová, 2014) is defined for the terms defined in the study material, particularly in the theoretical layer. The terms are highlighted by the author of the study material, who can also add synonyms of the term. The edges represent the relation of the following types: **predecessor** (term defined earlier and appearing in the definition of the current term), **successor** (term defined later whose definition contains the current term), **occurred before** (the term occurred in the study material before being defined), **occurred after** (the term occurred in the study material after being defined).

After the study material has been added to the LMS, the corresponding SNT can be created automatically without the author's interference.

The SNT is important for both the student and the author of the study material.

The author is provided with the evaluation of the study material on the basis of which they can then modify or update the study material and its variants before it is presented to the students. It generates a list of errors and highlights possible errors resulting from didactic principles, e.g. the use of undefined terms, defining terms with no further use, etc. Moreover, the SNT also automatically generates an explanatory dictionary of the course.

The SNT is intended particularly for the student. When the student studies the curriculum step by step as it is described in the textbook, situations may arise when they need to revise earlier terms which are related to the new curriculum. The SNT enables them to find both the definitions of the terms and the additional information without their having to "browse through" the study material. When the student asks a typical question "What is it good for?", the SNT immediately shows them both the theory related to the new term and how it can be applied in practical situations, e.g. when solving a task, etc. The SNT helps the student to develop the structure of terms and their context in their memory. When revising the curriculum before an exam, the SNT improves the student's orientation in the terminology. Visualization of a network of terms is better for remembering than plain text.

The use of an interdisciplinary SNT will make it easier for both the authors and the students to compare the definitions of terms, or alert the authors about possible discrepancies. The students are often not aware that the same term has the same meaning in various subjects and is only being discussed from another point of view, which results in them learning such terms again, overloading their memory and not understanding the relations between subjects. Therefore, the use of the interdisciplinary SNT will enable the students to see the same terms from a different perspective, which will improve their understanding of reality. Examples of such terms are: vector (mathematics, physics, programming), system (virtually everywhere), etc. The interdisciplinary use of SNT reveals the unnecessary duplicities in the instruction or possible discrepancies in definitions or their interpretation.

Pedagogical experiments with adaptive education

In 2013-2015, various experiments concerning the adaptive LMS were conducted, all of them related to dissertations of the students studying in the "ICT in Education" study program. They all drew on the theories described in Chapter 3 and led either to the extension of the expert rules or to the addition of new functions to the LMS.

The **foreign language instruction** theory, which uses all 4 of student's senses added to the LS characteristics in the order of decreasing significance, was verified on the sample of 200 students from the Silesian University in Karviná (Horký, 2014). On the basis of a questionnaire, the students were assigned the characteristics of their individual LS.

The main hypothesis was divided into several smaller partial hypotheses. A series of pedagogical experiments confirmed that the students who are taught a foreign language in the adaptive system are statistically more successful in mastering it than the students that are taught a foreign language in a non-adaptive system.

Also the theory of adaptive testing was verified in a pedagogical experiment on the sample of 53 students from a primary school in Ostrava-Poruba (Prextová, 2014). On the basis of a questionnaire, the students were assigned the characteristics of their individual LS.

A 6-unit mathematics curriculum including the revision for final examination in the 9^{th} grade was created for the use in the instruction. A pretest, individual study in adaptive e-learning and a posttest revealed that the proposed algorithm for the repetition with consultation mode and the proposed adaptive rules contribute to the improvement of students' knowledge and skills. The improvement is noticeable especially among the weaker students.

Further experiments using the SNT and the evaluation of instruction protocol by the analysis of instruction are being conducted in the 2015 fall semester.

Conclusion

In conclusion, we can say that:

- The formulated theory of adaptive education was incorporated in the new type LMS including all described possibilities of automatic adaptation of the study material according to the individual characteristics of the student's learning style;
- The theory has been expanded in several ways: by the theory of adaptive testing, the theory of the use of all senses during the instruction (in the order of decreasing significance), the use of the semantic network of terms for better orientation of the student and the author in the structure of terms; further theories are being developed;
- The abovementioned theories have been verified by pedagogical experiments.

New topics have been appearing during the research and development of individual adaptive e-learning education, which will be used not only as topics of dissertations. A permanent team of researchers, especially from the Department of Information and Communication Technologies at the Pedagogical Faculty of the University of Ostrava has been systematically working on them.

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ICT-SUPPORTED EDUCATION AT CZECH AND POLISH UNIVERSITIES: A COMPARATIVE STUDY

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Abstract

The comparative study defines the terms electronic learning environment and smart learning environment with their components and contribution to university education. Moreover, it introduces identified trends that are expected to emerge in the next five years. The research on a representative sample of the University of Ostrava students and the University of Silesia students, which was carried out within the scope of the 7th RP IRNet project, was aimed at how the individual components of the electronic learning environment can be used, the reasons for their use and the related needs of students.

Keywords

electronic learning environment, smart learning environment, development trends, research of students' opinions and needs

Introduction

Electronic learning environment at universities provides university teachers and students with technical, information and pedagogical environment for effective study, research, administrative and leisure time activities. It contains several basic components which are being further elaborated in accordance with the development in the ICT field, general teaching theories, university pedagogy and andragogy, pedagogical evaluation in education and other fields. The diversity of this environment with the many naming versions (which sometimes lack clarity and even seem redundant) has led to the formulation of the assessment criteria and their implementation and further development. As far as the development of this environment at universities is concerned, the trend is to ensure its contribution regarding the quality and equality of study. In order to adjust it to the needs of the current "digital students" (Švaříček, Zounek, 2008) and to reach its new development qualities (such as the "smart learning environment" or the "personal learning environment") a questionnaire research, the results of which are presented in this article (it contains the results of Czech university students), was conducted in each of the nine countries of the research consortium. The questionnaire research was conducted within the scope of the 7th EU framework program called IRNet *(International research network for study and development of new tools and methods for advanced pedagogical science in the field of ICT instruments, e-learning and intercultural competences).*

Generally, three main influences of ICT on education are postulated (Pickett)[1]. These have the potential to be enhanced in some way via the use of some technology. Technology can be leveraged to:

1) Present content in a more effective or engaging manner.
2) Facilitate collaboration or interaction with/between students in a more effective or engaging manner.
3) Provide feedback, or to assess/evaluate students in a more effective or engaging manner.

Neumajer (2013) identifies several main trends in the development of ICT in education: cloud computing, a phenomenon when the students bring their own devices (BYOD – Bring Your Own Devices), freely available study materials and DUMs, reverse education, massive open online courses (MOOC), the creation of the personal learning environment (PLE) or electronic textbooks.

Electronic learning environments and their development versions and contributions

There are various designations for electronic learning environment, which can represent its development phases or its potentially or actually used functional possibilities.

eLearning environments (ELE) are most commonly associated with the LMS Moodle, which can save files containing study materials, realize communication between the teacher and the students and between students, plan studies, assign and evaluate tasks, evaluate other students, test, save study results, etc.

Some authors use the term “virtual learning environments” (VLE) or “institutional learning environments” (ILE). However, these are difficult to tell apart; in fact it can be said that the two terms refer to the same environment.

As far as the so-called “smart learning environments” (SLE) are concerned, the term should reflect the interconnection of pedagogy and technologies. In the smart environment, pedagogy is represented by learning and assessment paradigms, social factors and policy. Technology includes emerging technologies, innovative uses of mature technologies, adoption usability and standards, and emerging/new technological paradigms (open educational resources, cloud computing etc). This initiative is supported by the established IASLE (International Association of Smart Learning Environments), which also holds conferences.

Hwang (2014) summarizes the potential contributions of SLE in three points:

[1] Alexandra M. Pickett, Associate Director SUNY Learning Network (USA) http://sln.suny.edu/

1) A smart learning environment is context-aware; that is, the learner's situation or the contexts of the real-world environment in which the learner is located are sensed, implying that the system is able to provide learning support based on the learner's online and real-world status.
2) A smart learning environment is able to offer instant and adaptive support to learners by immediate analyses of the needs of individual learners from different perspectives (e.g., learning performance, learning behaviors, profiles, personal factors) as well as the online and real-world contexts in which they are situated. Moreover, it can actively provide various personalized support to the learners, including learning guidance, feedback, hints and learning tools, based on their needs.
3) A smart learning environment is able to adapt the user interface (i.e., the ways of presenting information) and the subject contents to meet the personal factors (e.g. learning styles and preferences) and learning status (e.g., learning performance) of individual learners. The user interface is not necessarily a conventional computer. Instead, learners can interact with the learning environment via mobile devices (e.g. smartphones or tablet computers), wearable devices (e.g., Google Glass or a digital wristwatch), or even ubiquitous computing systems embedded in everyday objects. Therefore, it is a challenging issue to adapt the user interface to meet the learners' needs in a smart learning environment.

Another way of approaching the ICT applications in education is the creation and use of the so-called "personal learning environments" (PLE). Schaffert and Hilzensauer (2008) argue that contrary to the traditional learning management systems (LMS), the PLE systems were very well received and have the potential to change the paradigm of education. They identified seven aspects which reflect these changes in the most significant manner. Briefly speaking, studying within the scope of the PLE leads to the following changes: (1) the student has the role of active and self-directing creator of the content, (2) personalization as a result of the information and support of the members of the particular community, (3) the study content as an immense "bazaar", (4) social involvement playing a key role, (5) the ownership of students' data, (6) the significance of self-organized study for the culture of educational institutions and organizations, (7) technological aspects of the use of the social software tools and the collection of various sources. Johnson et al. (2006) summarized some of the critical objections to LMS systems, one of which concerned the inability of many institution-based LMS systems to afford the opportunity of greater peer-based pedagogy.

Milligan et al. (2006) argue that the PLE uses tools that would allow the learner to:

- **Learn with other people:** manage and create relationships, forming connections between contacts that are not part of a formal learning network.
- **Control their learning resources**: allow them to structure, share, and annotate resources they find or have been given.
- **Manage the activities they participate in:** provide opportunities for them to create as well as join activities that bring together people and resources.

- **Integrate their learning:** allow them to integrate learning from different institutions and sources, re-using evidence of competency and making links between formal and informal learning.

According to Malamed (2014), "A personal learning environment (PLE) is a solution for keeping up with the rapid pace of knowledge change. Some say it is a concept, while others say it is a technology". She offers the following definition: a self-directed and evolving environment of tools, services and resources organized by a person seeking a way to accomplish lifetime learning, to create, and to connect with others of similar interests. Because it is personalized, everyone's PLE will be unique. Because it is collaborative, information may be continually created and shared. In the workplace, designing a personal learning environment has the potential to partially replace conventional courses.

According to other sources (IMAILE, 2015), the PLE are "systems that help learners take control of and manage their own learning. This includes providing support for learners to: a) set their own learning goals (with support of their teachers), b) manage their learning, both content and process and c) communicate with others in the process of learning". The consortium of solvers of the project of the same name considers the following to be its main contributions:

- A personalized learning environment increases the students' motivation and creates a learning situation where they can control their own learning at their own pace.
- It allows students to actively design their own learning strategies
- PLE enables better contact between student/teacher, and the education is less teacher-centered.
- PLE and modern technology together create a customized learning environment that suits the development of the 21st century classroom.
- The technology of today makes it possible to create PLE solutions which are developed to suit the demands from both teachers and students.
- PLE in combination with technical tools increase the students' interest in STEM (Science, Math and Technology) subjects, which is important as there is a growing demand in STEM related professions.
- The young generation of today primarily learns by being interactive. This requires interactive classrooms with personalized ICT solutions.

Taraghi, B.; Ebner, M.; Kroell, C. (2012) describe the development of the PLE and the emergence of the specific solution based on the web 2.0 technology at Graz University of technology in 2010. The main idea in using a Personal Learning Environment is that there are many resources distributed on WWW that are driven in the learning process of the learners directly or indirectly. Nowadays universities and higher educational institutions provide their students with many online services such as LMS to enhance the learning performance and simplify the sophisticated learning process. At TU Graz a PLE has been launched that relies on mashup of widgets. Widgets represent independent resources, services and applications that are all integrated within PLE. Users can select widgets from a pool of widgets (widget store or widget boutique), arrange them as they prefer and configure them to their actual needs and interests. As a result of the implementation of the solution, the number of its users increased by 400 % compared to the original version.

In 2004-2008, within the scope of the iCLASS project, which was part of the 6th EU framework program[2], the so-called intelligent and knowledge-based open educational system and environment adapted to students' individual needs were created.

In 2010-2014, within the scope of the iTEC project[3], which was part of the 6th EU framework program[4], six factors of the successful use of ICT in education were defined: 1) Access to reliable and sufficient infrastructure, 2) Appropriate school ICT policies, 3) Pedagogical and technical support of teachers, 4) Teacher, pedagogical and digital competence, 5) Positive attitudes at all levels toward change, 6) Suitable digital learning resources. The number of factors demonstrates the experience of many schools and countries concerning the necessity to solve a number of related questions (mainly the support and training of teachers) when implementing ICT innovations.

When describing the contribution of the ITEC project, Lewin and McNicols (2014) argue that during its course a number of prototypes of new tools have emerged for the support of education (e.g. TeamUp for dividing students into teams); for learning design (Scenario Development Environment (SDE), which takes into account the user's profile (e.g. the school level and subject) and which can recommend sources such as applications, actions, widgets and lectures); or for cataloging of study resources (The Widget Store).

Lewin et al. (2013) also summarize the influence of the project on the ICT application field: "Detailed meta-analysis of the evaluation data over the first three cycles of iTEC shows that there is a positive impact on *students'* knowledge, skills and understanding – in particular 21st century skills, their motivation, engagement and attitudes and their learning practices. iTEC has also had a beneficial effect on *teachers*, impacting positively on their technology-supported pedagogy, digital competence, and their motivation, engagement and attitudes. Moreover, iTEC is seen as scalable, having the potential to support pedagogical and technological innovation, to increase the effective use of ICT and to encourage experimentation with innovative technologies and tools" (p. 7).

The example of new tools is illustrated by the expected development in the field of "personal" or "smart" learning environments, which will be continually updated with these and other tools in order to become more integral and user friendly toward teachers and students. The annual NMC (New Media Consortium) Horizon Report: 2014 Higher Education Condition formulated six key trends in the field of university education. The first two of the so-called "rapid trends" and the sixth "long-term trend", which deals with the development of online education, are from our area of research. The trends are as follows:

1) Growing Ubiquity of Social Media
2) Integration of Online, Hybrid, and Collaborative Learning

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[2] http://www.scientix.eu/web/gueteacher pedagogical and t/resources/details?resourceId=2918
[3] http://itec.eun.org/web/guest;jsessionid=AB1CBBA7B95A31E98EF78D7777C133A6
[4] http://www.scientix.eu/web/gueteacher pedagogical and t/resources/details?resourceId=2918

3) Rise of Data-Driven Learning and Assessment
4) Shift from Students as Consumers to Students as Creators
5) Agile Approaches to Change
6) Evolution of Online Learning

The significance of ICT tools in university education, which brings a certain degree of standardization of resources, is supported by the authors' critical view of underappreciation of teaching activities at universities. They argue that "*According to the Times Higher Education's World University Rankings methodology, research and citations account for 60 % of a university's score, while teaching is only half that. There is an overarching sense in the academic world that research credentials are a more valuable asset than talent and skill as an instructor. Because of this way of thinking, efforts to implement effective pedagogies are lacking" (p. 26).*

The LMS Moodle has been used at the University of Ostrava for almost 10 years. Therefore, it is logical that the respondents were evaluating this environment and working in it. The LMS Moodle is a system for the management of education, which – despite its relatively short existence – is unrivaled as it is the world's leading system of its kind in the field of school and business education. Therefore, we can argue that Moodle is the most widespread LMS system both worldwide and in the Czech Republic. Through this system the standard procedures, which occur in common education, are being continually electrified – these are mainly students' educational processes managed by textbooks and study texts.

Moodle enables the creation of simple courses, which consist of a collection of study texts, as well as the most elaborate interactive courses, which use all the available technologies that today's computers and eLearning offer. The creation of courses has six levels:

0) The course contains only the basic information about the subject, it contains no study materials, such a course is sometimes called an "empty" course
1) The teacher posts study materials (mainly texts and presentations) which the students can browse or download
2) The course contains communication instruments (discussion forums, chat, e-mail, blogs, etc.), which enable students to communicate with the teacher or with their fellow students and thus present their opinions
3) The teacher can manage the education process, assign tasks, test students' knowledge and evaluate them
4) The course contains interactive, multimedia and dynamic aspects such as animations, video sequences or computer simulations of the discussed phenomena
5) The teacher can manage the activity of individual students and individualize it; on the basis of the student's previous results, the teacher can, for instance, influence which tasks they should solve.
6) The students can actively add their own notes or resources to the study materials and thus modify the entire course.

Nowadays, the Pedagogical Faculty of the University of Ostrava mainly offers the level 4 courses and some level 5 courses.

The Faculty of Ethnology and Educational Science conducts research tasks in the field of pedagogy and ethnology. The staff conducts projects within both these disciplines. The faculty is situated in a border town and in the heart of multicultural Cieszyn, Silesia region is the main determinant of the research profile. The Faculty educates 3 000 students of pedagogy. The process of academic education comprises such courses as e.g. multi- and intercultural education, computer science and information technology. Students make use of the faculty distance learning platform, based on the MOODLE system, which enhances future teachers' preparation for applying e-learning in their work and for undertaking the function of a tutor.

Research on use of electronic learning environment by University of Ostrava and University of Silesia students

Research objectives

The subject of the research was the use of the electronic information environment (EIE) by the university students. The goal of the research was to collect and analyze data about the current situation concerning the use of individual components of the electronic information environment and learn whether it varies in various forms of study.

Research problem and research questions

The authors of the study formulated the basic research problem as follows: There are no relevant data concerning the University of Ostrava students' (RC) and University of Silesia´students´ (PL) use of electronic information environment instruments, which kinds and why the students of the particular university use them and what their needs and expectations are as far as this area is concerned. The formulated research problem was further specified by the following research questions:

1) Which components of the electronic information environment do students use?
2) What are the reasons for students' use of the electronic information environment?
3) What could have a positive impact on students' activity concerning the use of electronic information environment and which parameters of the environment could influence this activity?
4) Should be students' personal needs taken into account when developing the sources of the electronic information environment? If so, which are they?
5) Which components of the electronic information environment can influence a student's choice of university the most?
6) In students' opinion, in which way could some of the instruments of the electronic information environment influence the planning of their study activities?

Research file and data collecting

The students of the Pedagogical Faculty of the University of Ostrava were the first part of research file of this research. All of the students were asked through a bulk email to fill out a questionnaire, which was compiled by a consortium of project solvers. 171 (5.4 %) out of the total number of 3161 students who studied at the Faculty in the 2014/15 academic year filled out the questionnaire in the Google electronic environment. Considering that students' participation in the questionnaire research was voluntary, the selection of respondents was random. Furthermore, considering the portion of the total number of students and the approximately same number of DA and CS students (1761 (55.7 %) DA students and 1405 (44.3 %) CS students are studying at the Faculty), the sample can be considered representative

In Poland, the research was conducted at the Faculty of Ethnology and Education (in Cieszyn) of the University of Silesia in Katowice. In total, the studies comprised 100 people. The respondents were students of pedagogy. What is not presented due to the homogeneousness of the group are the analyses taking into account the variables associated with the division of students.

Results and their interpretation

The research results were processed using the statistical program and are being presented in the order of the sequence of the research questions.

Research question 1 results: Used components of the electronic information environment

The students answered the question "Which information resources do you use most often when solving assignments, conducting a research, writing papers?" Yes or No in all of the 8 variants: 1) search engines (Google, Yandex, etc.) – a keyword search, 2) printed publications (books, journals, guidelines, etc.), 3) electronic scientific databases of the university library (the database of electronic journals, full-text electronic resources, etc.), 4) digital libraries on the Internet, 5) Open storages of electronic educational resources (repository, WIKI), 6) video channels (YouTube), 7) file sharing, torrent, 8) webinars, podcasts. The data presented in Graph 1 show the following:

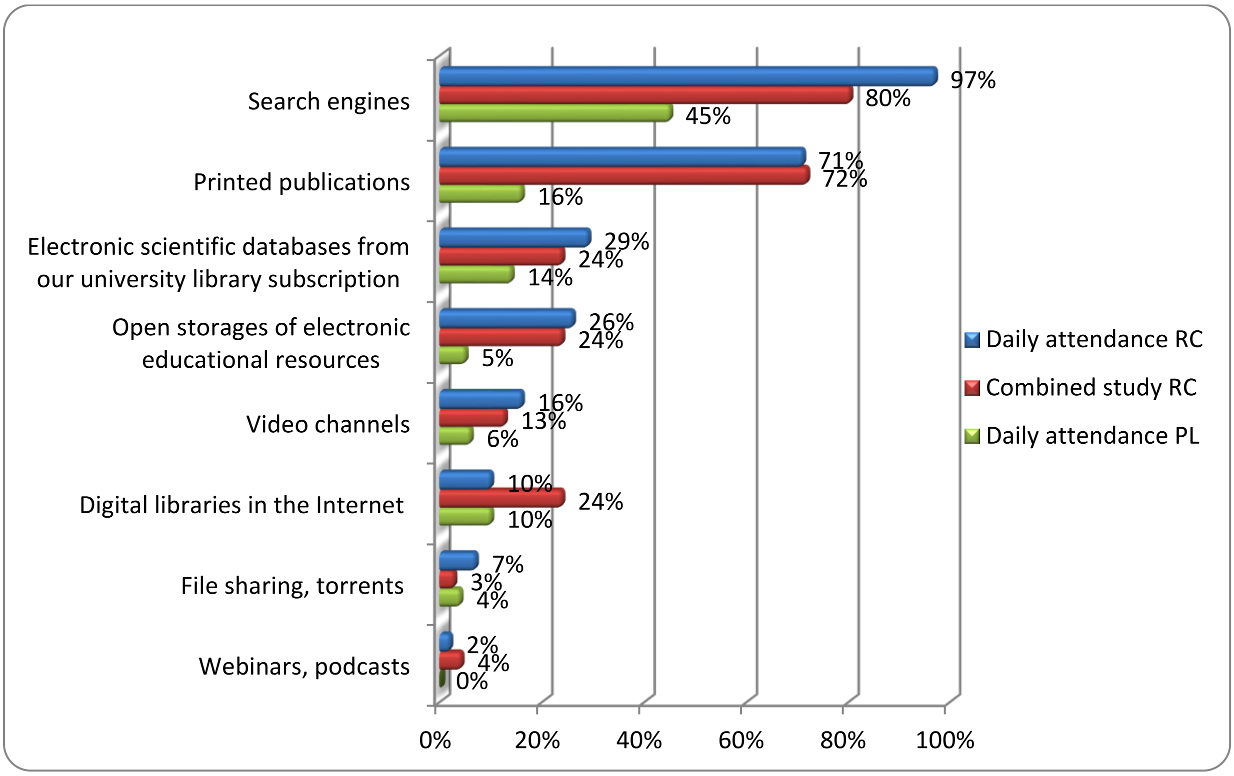

Fig. 1: EIP components used by university students in the Czech Republic and Poland.

Czech students

- largely use search engines in their work (90 % of students).
- they still work with printed publications (71 %).
- however, they use electronic scientific databases (26.9 %) and digital books (15.8 %) to a small extent. Every fourth student (25.1 %) uses stored data or saves their own data in open storages of electronic study materials. Every eighth student (14.6 %) uses video channels. Students hardly ever make use of webinars or file sharing.
- the DA students use the mentioned resources to the same extent as the CS students. The CS students work more with digital libraries and less with search engines. It can be said that the CS students have a more targeted approach to searching and using of study materials.

Polish students

- Comparing the data concerning the Czech Republic to the results obtained in Poland, it is worth noticing that in general the percentage of Polish students using internet resources for educational tasks is lower.
- Search engines (Google, Yandex, etc.) are used by 45 % of respondents.
- Printed publications (books, journals, guidelines, etc.) – by 16 %.

- Scientific database of university libraries (database comprising electronic journals, textbooks, full text resources, etc.) was indicated by 14 % of respondents.
- Open storage of electronic educational resources was indicated by only 5 % of the examined students.
- Video channels (YouTube) are not commonly used either – only 6 % indicated them.
- File exchange services (torrents) are not popular as well – 4 % of indications.
- Webinars and podcasts were not pointed out at all.

Research question 2 results: Reasons why students use the electronic information environment

Students answered to the question "Why do you (not) use those resources?" in order to learn the reasons for their (non)use of EIE instruments. The question could be answered by selecting one of the four offered answers: 1) I use them only if it is required by the teacher, 2) I use them because they make it easier to perform the tasks, 3) I do not use them because I don't know how they could help me, 4) I do not use them and rather search for the alternatives on the Internet (e.g. massive open online courses, etc.). The data presented in Graph 2 (the results are classified according to the respondents�' form of study) show the following:

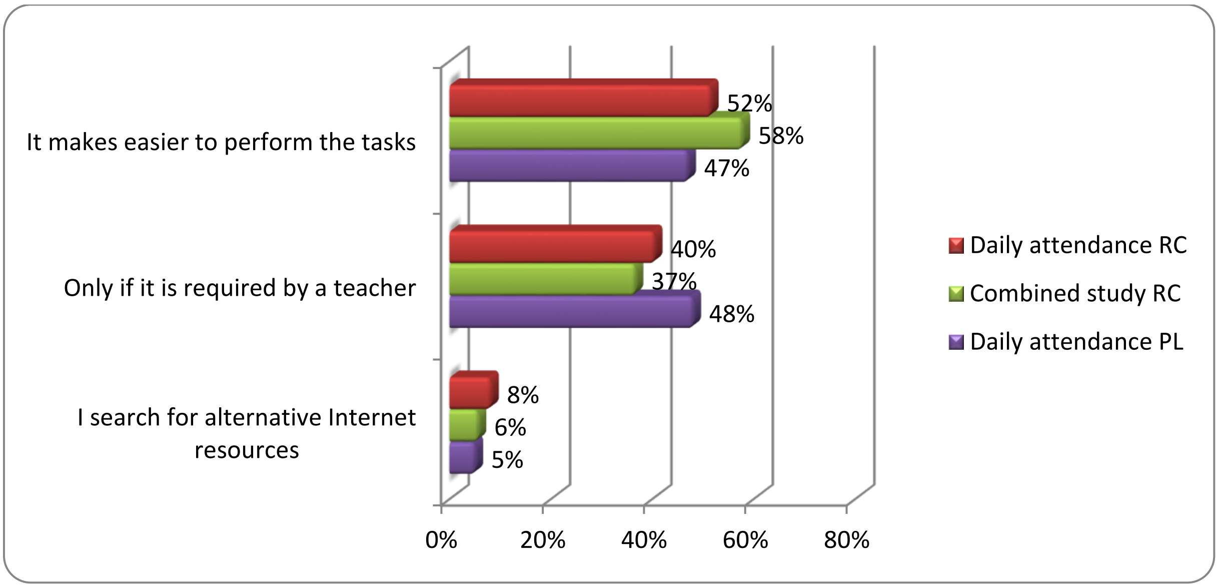

Fig. 2: Reasons for using EIP by students from Poland and Czech Republic.

Czech students

- For both forms of study, the EIE is used because it is required by the teacher (40.0 % and 36.6 % of students).

- The CS students use the resources more of their own will because they help them meet the requirements. Only one DA student stated that he/she did not use the resources and 5.6 % of the CS students search for the alternatives on the Internet.
- The similar number of both the DA and CS students states the reasons for their (non)use of the EIE instruments.

Polish students

- For 47 % of students from Poland, applying electronic educational resources is directly associated with assignments of the lecturer, who indicates such sources as indispensable for performing tasks.
- Only 15 respondents more (48 %) use these resources because of the benefits they provide in making tasks easier.
- A smaller percentage than in the Czech Republic (5 %) declares that they do not use electronic educational resources.

Research question 3 results: Factors potentially influencing students' activity concerning the use of the electronic information environment

The factors were being determined from the students' answers to the following question: "Which would be the two main reasons that would increase your interest in the active use of the university EIE resources?" The students were asked to choose two of the four following answers: 1) It would make you acquainted with the possibilities of their use, 2) Your using them would be refleced in your evaluation and grades, 3) It would enable you to perform assigned tasks at your own pace, anytime and anywhere, 4) It would help you find more diverse electronic resources. The data presented in Graph 3 show the following:

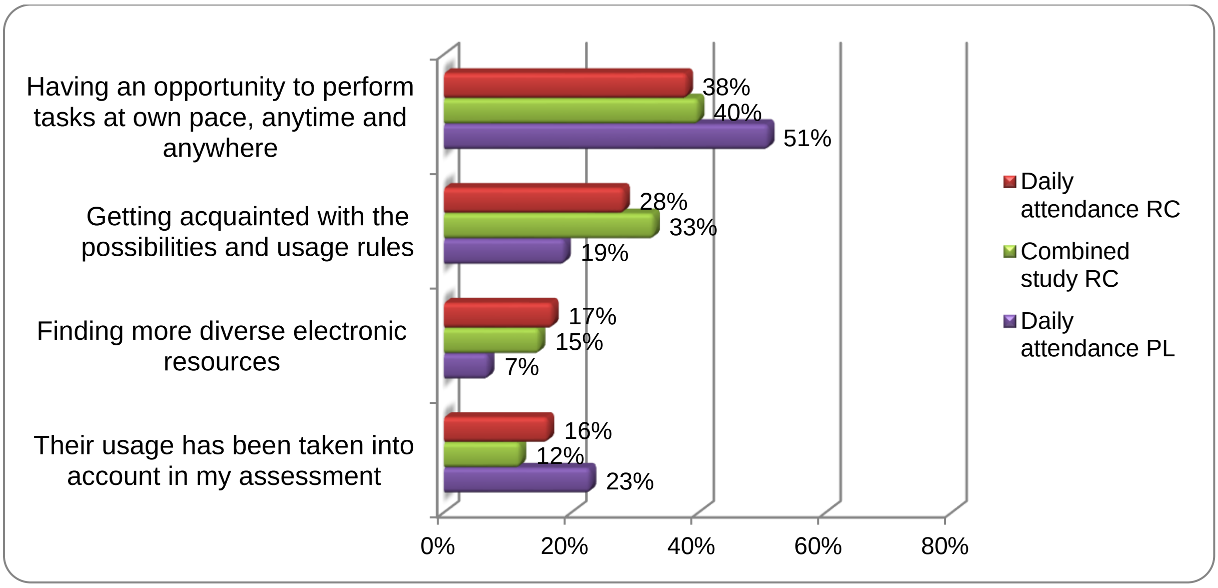

Fig. 3: The reasons of more active use of EPI indicated by students from Poland and Czech Republic.

Czech students

- Nearly 39 % of the 252 reasons stated by the students was the possibility to perform the assigned tasks at their own pace.
- Next in line (30 % of all answers) was the opportunity to become acquainted with the possibilities and advantages of their use. The remaining two reasons accounted for 15 % and 16 %, respectively of the answers. Therefore, one of the main advantages of the EIE was confirmed: a student's time flexibility when using it.

Polish students

- Also among Polish students the most frequent answer was making it possible to fulfil tasks in one's own pace in a more comfortable way – 51 % of declarations.
- Much more significance is attributed by Polish students to the situation associated with evaluation – 23 % indicated this as significant.
- For 19 %, it is important to be taught how to use properly the electronic resources of the university.
- The fewest (7 %) focused on the issues concerning the amount and diversification of the resources.

Deciding about the more active use of the EIE resources is connected to students' opinions on the functionality or availability of its instruments and components. The respondents could choose one of the six provided answers which would signal their preferred indicator for assessing the EIE: a) availability of Wi-Fi access points, b) opportunity to use their own gadgets, c) availability of electronic educational resources in different formats (video, audio, hypertext, etc.), d) university website with relevant information and easy navigation, e) availability of distance support for individual subjects (tasks in electronic form, electronic journals, course website or Moodle), f) immediate feedback from the teacher. The data presented in Graph 4 provide specific results:

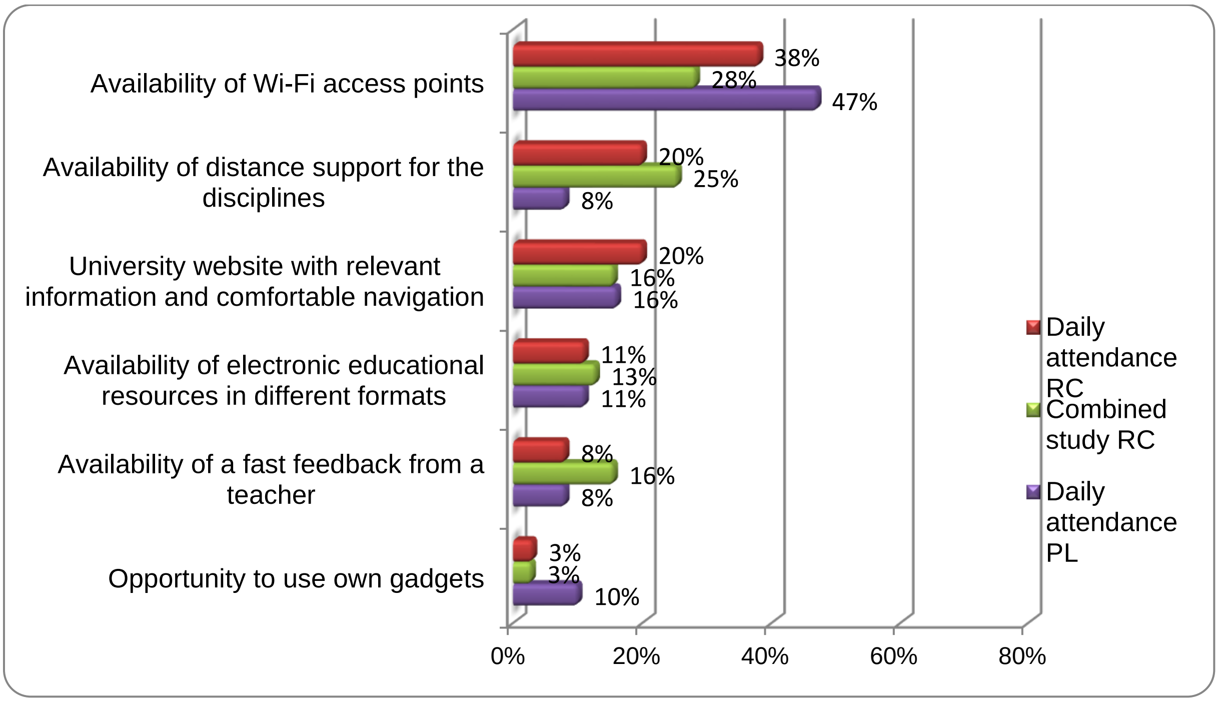

Fig. 4: Criteria of applying EPI by students from Poland and Czech Republic.

Czech students

- Students mostly prefer the availability of Wi-Fi access points (38 %), then the availability of distance support, e.g. in the form of Moodle (22.2 %), and a quality university website.
- The DA students, who spend more time at school than the CS students, find the availability of Wi-Fi access points more important than the CS students.
- The CS students, on the other hand, prefer the availability of distance support and immediate feedback from the teacher. It can be said that the CS students are more interested in the specialized EIE instruments than the DA students.
- Male students find the availability of Wi-Fi access points more important than female students and at the same time find the availability of distance support and immediate feedback far less important.

Polish students

- Students from Poland indicated the significance of Wi-Fi accessibility more often than students from the Czech Republic (47 %).
- Only 8 % of students from Poland pointed at the importance of the availability of electronic educational resources in various formats.
- For 16 % it is significant how the university website has been prepared – as regards both the information comprised here and the easiness of its use.

- The availability of distance support (tasks in electronic form, e-journals, websites of particular disciplines or distance learning system Moodle, or another LMS system) was indicated by 11 % of respondents and slightly fewer (8 %) indicated the significance of teachers' fast feedback.
- More Polish than Czech students (respectively 10 % and 3 %) indicated the possibility to use their own gadgets.

Research question 4 results: Students' personal needs concerning the EIE

Through the Yes/No question it was being determined whether or not "Should teachers take into account students' needs and interests while creating resources in the electronic environment (presentations, websites, tests, video lectures, etc.)? The question focused on learning the students' possible expectations concerning the creation and use of personalized/adjusted resources created by their teachers – the "No" part of the answer had a postscript which read "I can use the resources myself according to my needs" and the "Yes" part had a postscript that read "They should provide me with the resources adapted to my needs". Which resources adapted to their current needs the students would welcome in the EIE was learned from the additional question with 4 possible answers: a) foreign language study, b) acquiring another profession, c) information about start-up companies and the students' own business options, d) other.

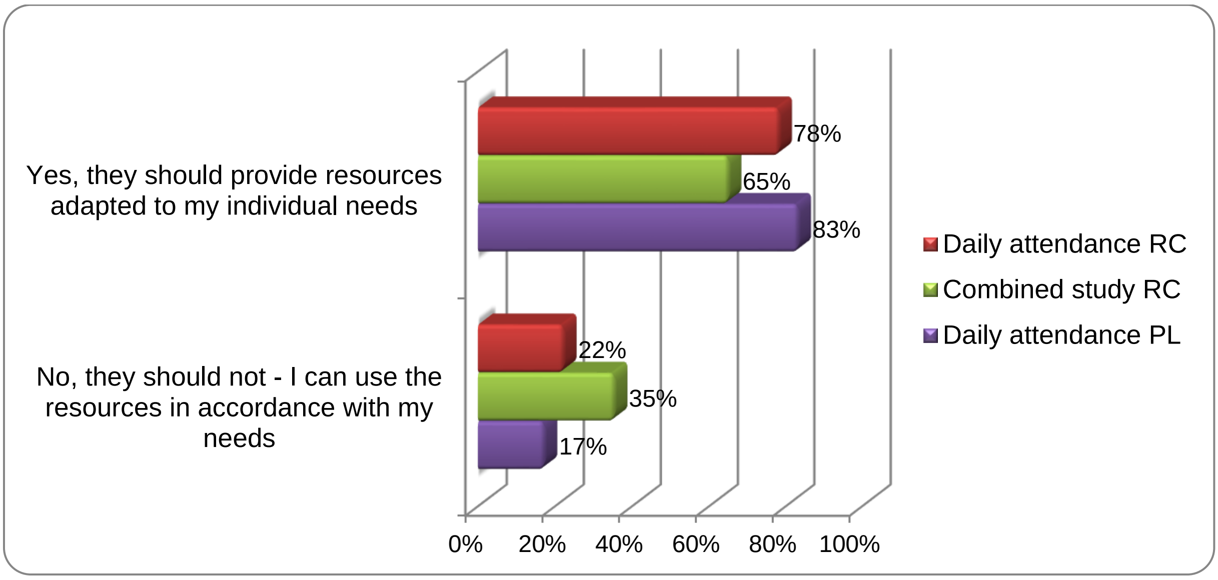

Fig. 5: Needs of EDP students from Poland and the Czech Republic.

The data presented in Graph 5 show the following:

Czech students

- Nearly two thirds of students (72 %) would welcome if the educational resources were adapted to their own needs. Male students would welcome this option even more (77 %).

- 78 % of the DA students answered this question in the affirmative. On the other hand, only 65 % of the CS students answered this question in the affirmative. The difference can be interpreted as follows: the CS students choose their own study resources, they are used to them and do not expect their teachers to create resources adapted to their needs.

Polish students

- Students from Poland more often pointed at the significance of individual treatment taking into account their needs and interests – 83 %. This aspect has no significance only for 17 %.

As far as the choice of possible additional study resources is concerned,

- 57 % of all Czech respondents would welcome resources for the study of foreign languages, 48 % for the acquisition of another profession, and 18.7 % for the information about start-up companies and their own business options. Due to their job responsibilities, the CS students are less interested in the information resources about other job possibilities and their own business options than the DA students.
- Most frequently, students from Poland pointed at the need for introducing additional educational services in learning foreign languages (44 %). Slightly more rarely, they chose the answer associated with obtaining an additional profession (36 %). What is important for 20 % is the information about newly created firms and the student's own firm.

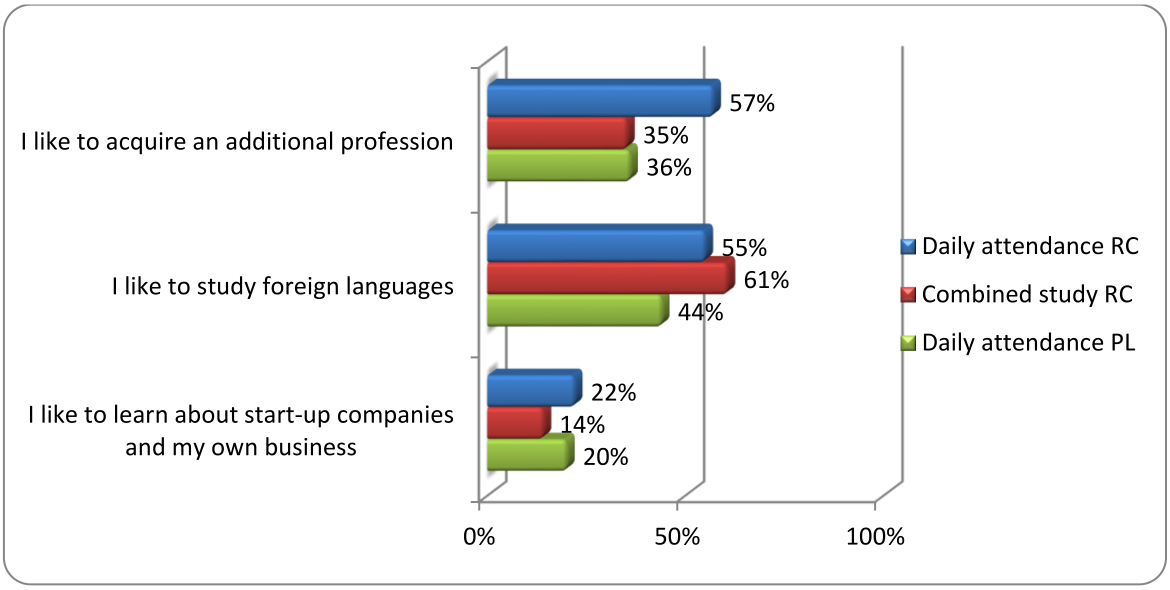

Fig. 6: Additional services within EDP indicated by students from Poland and the Czech Republic.

Research question 5 results: The EIE components potentially influencing the students' choice of university

The main point of determining which EIE components of a particular university the students find the most important when choosing a university was to learn the students' specific expectations concerning study conditions and the quality of the educational environment. The respondents were instructed to choose the most important of the following answers: a) university massive online courses, b) an attractive and user-friendly university website, c) university social network, d) transparent presentation of the university teachers' achievement on the university website (awards, publications, etc.), e) transparent presentation of the university students' achievements on the university website (awards, publications, etc.), f) information about successful university graduates and their achievements, g) collaboration of the university with schools, kindergartens, educational centers, firms, etc., h) participation of the university in social activities and cultural life (volunteering, charity concerts, exhibitions, etc.).

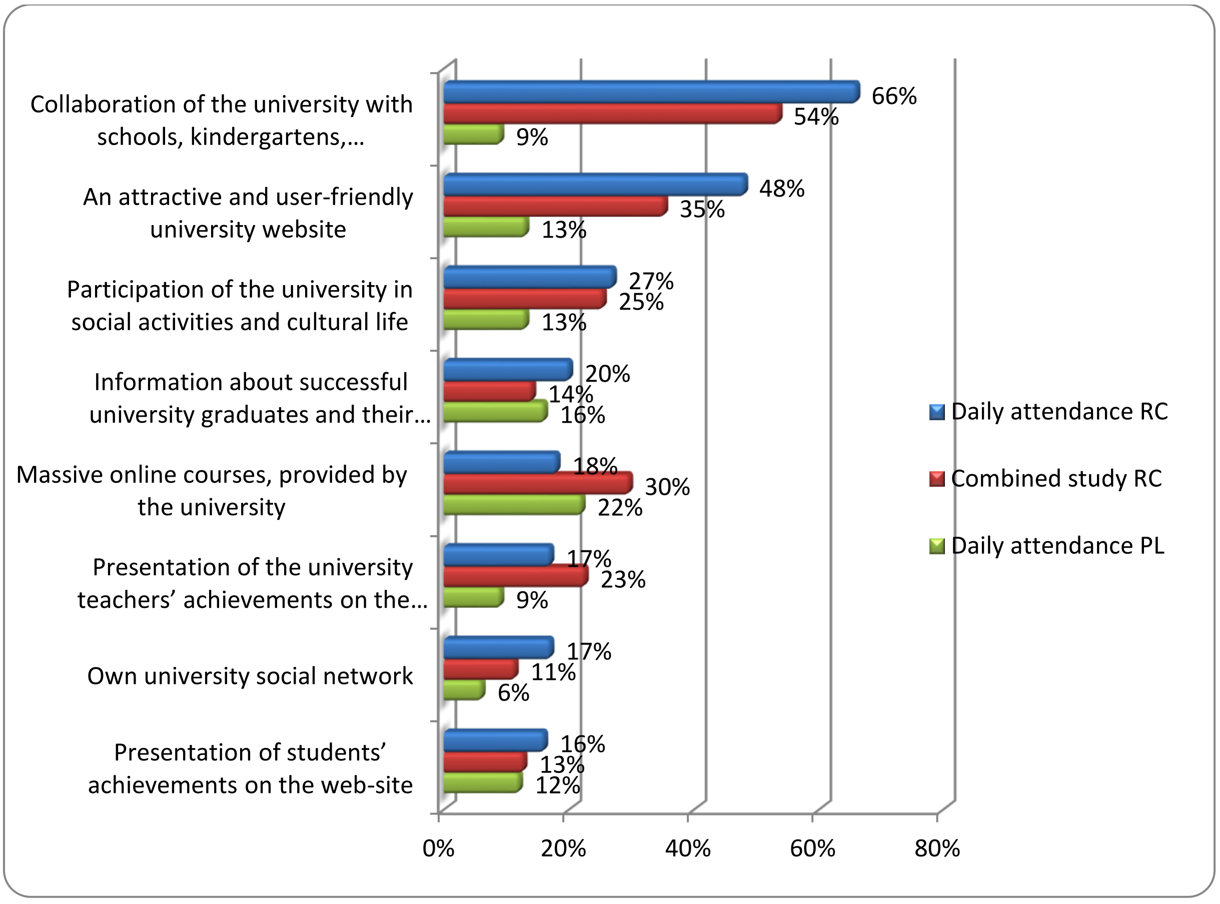

Fig. 7: Potentialities of EPI as the basis for choosing a university indicated by students from Poland and the Czech Republic.

Czech students

- It is surprising that the largest portion – 27.8 % - of the entire number of respondents' answers (374) representing their opinion on the influence of the factors on the choice of university was represented by the information about cooperation of the university with lower level schools. As far as the number of students who stated this factor is concerned, the portion is 60.8 %. It can be the result of 83.6 % of the research sample students studying in the teacher study program. 62.2 % of the teacher study program and 53 % of the specialized program students considered this factor to be the most important.
- An attractive university website is the second most important factor (19.5 % of all answers) followed by the participation of the university in social and cultural activities.
- As far as the DA students are concerned, the portion of answers preferring the influence of information about the cooperation of the university with lower level schools is higher (32.7 % of all answers) than the CS students' (29.9 % of all answers). Moreover, the DA students also appreciate the significance of an attractive university website more than the CS students.
- On the other hand, the CS students – as expected – stress the importance of the university massive online courses, the presentation of the university teachers' achievements and the participation of the university in social and cultural activities.

Polish students

- Students from Poland significantly more seldom indicated particular forms of the information space as determiners of their choice of a particular university level school.
- Most frequently (22 % of all respondents), students pointed at implementing online courses at university.
- Students' successes described in the information space are treated as important by 16 %. 13 % of indications appeared in the case of two answers – an attractive university website and functioning of the university own social network.
- Presenting the issues of social life and implemented activities (e.g. associated with voluntary service or charity actions) were indicated by 12 % of respondents.
- Students from the Czech Republic most frequently pointed at the presentation of cooperation between the university and schools, kindergartens or other environments which might hypothetically offer work for graduates (over 60 %), whereas this answer was indicated only by 9 % of students from Poland.
- The same number of indications appeared in the case of information concerning achievements of graduates.

Research question 6 results: Students' opinions on the influence of the EIE on the planning of their study activities

Determining these opinions can be interesting from the point of view of time management, which is – with regard to the preparation of the majority of students for the teaching profession, which requires not only management of one's own time, but also of their students' time – a significantly important skill. The answer to the research question was obtained through the processing of four proposed answers to the questionnaire question "Would the information technology instruments (electronic diaries, planners, calendars, reminders, etc.) help plan students' educational and extracurricular activities?". These are the four possible answers: a) no, they would not have a significant influence, b) yes, they would help me significantly with organization, c) my study activities are adequately coordinated by teachers and administration, d) I already use the tools, but I do not find them helpful.

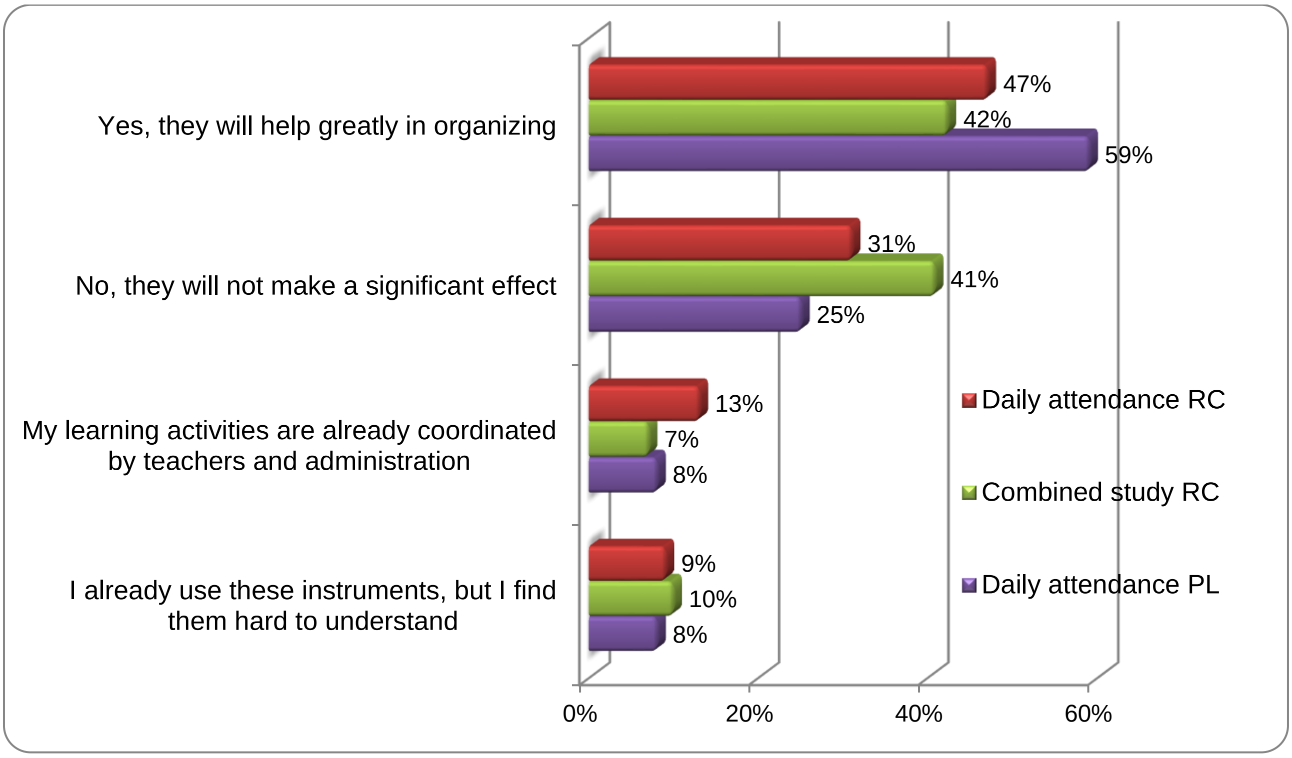

Fig. 8: Potentialities of EPI as the basis for planning indicated by students from Poland and the Czech Republic.

Czech students

- Nearly half of all the Czech students (45 %) think that the EIE instruments will help them in the planning of their educational and extracurricular activities.
- The CS students are more skeptical – every fourth CS student believes that the EIE instruments will not help them with time management. The fact that they have already chosen other possibilities such as classic recorders, diaries, etc. and do not intend to change their habits may be one of the reasons.

- Every tenth female student is not using the instruments yet, but 46.8 % of them are contemplating using them (more than male students).

Polish students

- The last question subjected to analysis concerned planning the own educational activities with the application of EPI. Both students from the Czech Republic and Poland (59 %) most often claimed that these tools helped them in organizing the educational activities which they implemented.
- However, for 25 % of respondents from the University of Silesia this has no significant influence.
- The other answers were indicated by 8 % of the respondents, who confirmed that their classes were coordinated by the teacher and that they already used these instruments – yet they were not significant for the examined students.

Conclusion

The aim of the comparative study was to find out (based on the questionnaire research results) if or to what extent the answers of the Czech and Polish students to research questions differ.

- Students from Poland did not use the Internet as an information resource as often as students from the Czech Republic.
- Students from Poland used ICT as a result of encouragement from teachers more often than students from the Czech Republic.
- Students from Poland stated the possibility to solve the assigned tasks at their own pace, anytime and anywhere to be the reason for the more frequent use of ICT more often than students from the Czech Republic.
- Students from Poland indicated the significance of Wi-Fi accessibility more often than students from the Czech Republic
- Students from Poland more often pointed at the significance of individual treatment taking into account their needs and interests than students from the Czech Republic
- As far as additional resources are concerned, students from Poland and the Czech Republic would prefer if they could use them when learning a foreign language.
- When choosing a university, students from Poland would take into account its selection of online courses more often than students from the Czech Republic. On the other hand, students from the Czech Republic considered the cooperation of the university with educational practice and a high quality website to be more important.
- Students from Poland expected ICT to help them plan and organize their educational and extracurricular activities more often than students from the Czech Republic.

The research results can help academic scholars evaluate the possibilities of influencing university students, particularly their use of ICT and its tools in education, their information needs and encourage them to use ICT applications for both study and extracurricular activities. This would help improve the level of the so-called digital literacy of university students, which is and will continue to be desirable and even necessary in professional life. The comparison of the questionnaire research results of students from two universities in two geographically close countries indentified certain differences in the "digital behavior" of university students, which can be explained by either random factors resulting from different structures of the two researched groups or other factors, e.g. the length and content of students' entry preparation concerning the use of ICT in education, the availability of ICT at the university, or students' own ICT devices (and as far as the Czech students are concerned, also the form of study). Using statistical analyses, subsequent researches will examine the possible impact of those factors on larger research samples.

Acknowledgments

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ICT TEACHERS, SOCIAL NETWORK SITES AND ONLINE PRIVACY

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Abstract

The article looks at primary and secondary ICT teachers' attitude to social network sites and privacy protection on the Internet. Attention is devoted to student-teacher friendships within online network sites. The study includes a description of specific habits as well as a discussion of how teachers make decisions and what influences them.

The research has used in-depth semi-structured interviews, focusing on ICT teachers with differing views on the issue in question. Our investigations have been supported by triangulation, which involved accessing information about given teachers on social network sites. Data gained from interviews and triangulation has been processed using open coding.

The results of our investigation show that teachers appreciate SNS because of the possibility to communicate and keep in touch with people they know, including former pupils. Teachers are concerned about the risks associated with using SNS, particularly security and privacy risks, and they feel even more under threat due to their occupation. Some teachers decided not to reject their pupils' friend requests for educational reasons, claiming SNS serve as a channel of communication to support teaching and learning.

Keywords

social network sites, Facebook, ICT teachers, e-safety, routines, privacy, open coding

Introduction

One of the current ICT issues is the protection of user privacy, particularly on social network sites (abbreviated SNS). The main emphasis is placed on children and youngsters. Their behaviour on SNS has been the subject of a number of studies such as (Hinduja and Patchin, 2008) and (Ofcom, 2011). As stated by Kapoun, Kapounová and Javorčík (2011), most young people use their computer on a daily basis as a means of communication. However, due to their lack of experience, knowledge and ability to cope with certain situations, they are relatively risk-prone (OECD, 2011). One example quoted by the OECD (2011) is that children often wrongly suppose that personal information posted online will not go any further than where it was sent. Overall, young people are more likely to share private information than older people (Get Safe Online, 2010). However, such behaviour could put their future at risk as some colleges and universities have visited an applicant's social networking website as part of the admissions decision-making process (Wong 2008) and a large number of employers do the same (Cross-Tab, 2010).

Being the closest, parents should be approached when children and teenagers need to ask for advice. However, they are often only familiar with the ICT they use at work (Kapoun, Kapounová and Javorčík, 2011) and feel unequipped to help children in the digital world (Byron, 2008). Ofcom (2011) has revealed that two thirds of parents believe that their children, aged 12 to 15, have a better knowledge of the Internet than they do. As children and young people need to be encouraged to stay safe (Byron, 2008), the role of the school needs to be prioritized. Becta (2005; 2007) claims that schools ought to take most responsibility for leading pupils to critical thinking and suitable behaviour that will protect them from the risks associated with Internet use.

Social network sites in the school environment

A widespread trend in a number of schools is the regulation of pupils' use of the Internet, possibly blocking unsuitable websites and SNS (Sharples et al., 2009). However, as suggested by Valcke et al. (2007), such intervention will not develop pupils' e-safety skills. The Federal Communication Commission (2012) disapproves of blocking SNS, preferring the idea of pupils being guided to use these technologies suitably. Moreover, SNS are considered by some researchers as education-friendly technologies (Maranto and Barton, 2010).

The teachers' personality has proved to be important as he should set his pupils examples in terms of privacy protection (Buettner et al., 2002). However, a number of teachers lack personal experience in terms of e-safety, not having gained enough background knowledge – indeed they have never personally formed online relationships themselves (Chou and Peng, 2011). Phippen (2011) found that about three fifths of teachers use Facebook, about a third of teachers use Skype and approximately one seventh of teachers use Twitter.

The risks of teachers' presence on social network sites

Teachers' use of SNS is a highly controversial issue and teachers are increasingly required not to be present on SNS like Facebook or MySpace (Simpson, 2008). There have been cases of teachers being dismissed because of their inappropriate behaviour on SNS and possible unprofessional contact with pupils (Simpson, 2008).

Although two thirds of teachers worldwide consider friendship with pupils on SNS risky, around one third of teachers worldwide have friendships with their pupils on SNS (Symantec Corporation, 2011a). However, the situation differs greatly among individual states; information on European countries is shown in Fig. 1. Teachers may become victims of abuse in an online environment. Phippen (2011) claims that around a third of teachers or their colleagues have experienced this. Pupils were involved in two thirds of the attacks, their parents in one fifth and other staff in one in ten cases (Phippen, 2011). Sharples et al. (2009) claims that negative experiences caused by students using Web 2.0 were frequently encountered by one in twenty teachers, occasionally by one in five teachers and rarely by a quarter of teachers.

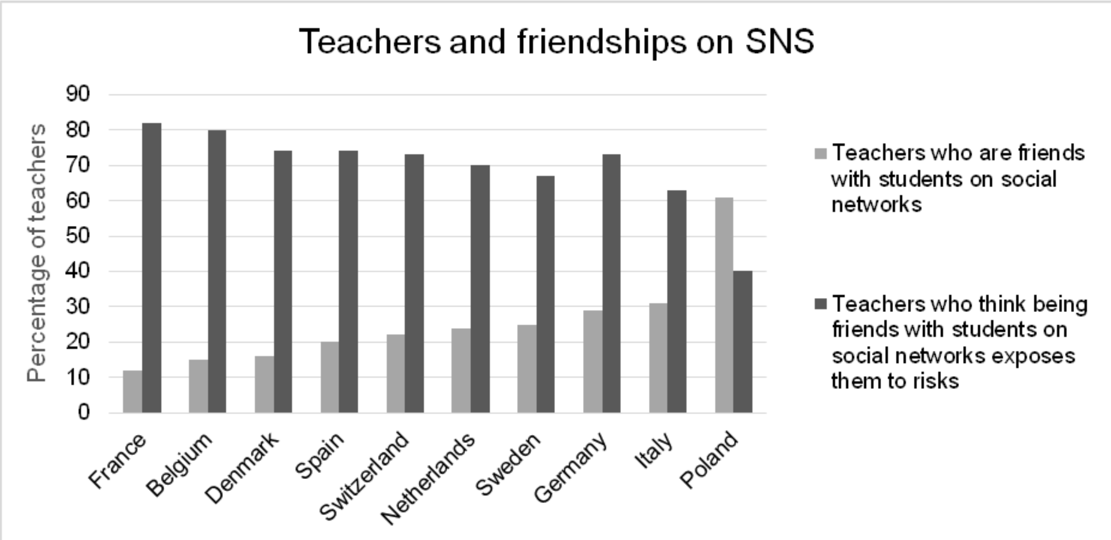

Fig. 1: Teacher-pupil friendships on SNS (according to Symantec Corporation 2011b)

A study of ICT teachers' behaviour on social network sites and the protection of their online privacy

Given the above mentioned findings, we decided to carry out a study focused on ICT teachers' behaviour on social network sites and the protection of their online privacy. Its aims are as follows:

- To explore how ICT teachers use social network sites and protect their online privacy.
- To analyse the reasons why teachers behave in such a way.
- To investigate how teachers' decisions are influenced by their occupation, particularly in terms of teacher / pupil interaction.

Methods

The study was carried out at the same time as our research on knowledge and routines of ICT teachers as regards technical e-safety (Šimandl, 2015). Therefore, the sample of study participants and research methods are similar. The study was designed and carried out as qualitative. Participants chosen for the study were primary, lower secondary and high school teachers of Informatics, Information and Communication Technologies, ICT and other similar subjects. 15 participants were interviewed in the study, chosen according to various factors – ICT teacher qualification, type of school (lower secondary or high school), length of service, size of towns where teachers work, age and gender.

Three of the study participants were qualified high school ICT teachers with relatively little experience in schools (approx. five years). Two participants were teachers teaching ICT for their first and third year but not qualified to do so, each with a very different approach to ICT self-study. Another two participants were trainees having completed teacher development studies for ICT coordinators. Although neither of them is a qualified ICT teacher, they have long-term experience of teaching ICT at high school, interest in the field and further education in it.

In order to include participants with experience at lower secondary schools in the study, two lower secondary school teachers were approached. They had already cooperated through short-term teacher development programmes before. Both teachers were employed in schools in smaller towns. Another participant was chosen due to his position as headmaster and another three teachers not qualified to teach ICT were added to the list. For these three, there was no evidence of them having attended courses or ICT teacher development. These participants were chosen particularly for their age, ranging from around 35 to 65. The last study participant was selected for his enthusiasm towards SNS and pupil friendships in the online environment.

Data collection

Data collection involved individual meetings with each study participant. A semi-structured in-depth interview formed the basis of each meeting. Study participants were informed of the aims of the study and assured anonymity. They were subsequently requested to take part in the study and to agree to have their interview recorded on a voice recorder.

The triangulation concept was incorporated into data collection (Švaříček, 2007). This involved exploring publically accessible information about the teacher's "virtual life" on the Internet, particularly on Facebook. Our focus of attention was placed on whether the teacher is registered on Facebook, what kind of information he presents there and whether he accepts pupils as friends. If we had been unable to find a particular teacher on Facebook before the interview itself and the teacher spoke of his activity on SNS during the interview, we made efforts to find him on Facebook subsequently.

Data analysis

Analysis of acquired data was based on the open coding method. The analysed text was divided into units and these units were allocated a certain code that represents a certain type of reply and differentiates it from the others (Šeďová, 2007). Codes from the generated list were subsequently grouped into categories according to internal similarity (Strauss and Corbin, 1999). The principle of constant comparison was included in the process of overall analysis (Šeďová, 2007). The aim of this comparison was to find differences within data sources relating to one study participant and within data concerning various participants.

Results

Analysis of the interviews identified several categories related to teachers' attitudes to SNS (especially Facebook and Google+) and to maintenance of their privacy and how they are formed. The most important categories are Specific protection routines on SNS, Causes of behaviour on SNS and Evaluation of others. Further categories were discovered during the study, some of them having been described in (Šimandl, 2015). The following text goes on to describe each of the categories mentioned above.

Specific protection routines on SNS

The category Specific protection routines on SNS concerns specific ways ICT teachers use SNS and to what extent, how they protect their privacy therein and whether they accept their pupils as friends.

The extent ICT teachers use SNS. The teachers differ greatly as to the extent they use SNS. While some claim not to use SNS, others use SNS occasionally and another group use them often (as shown in Case study 1). There are also differences in the ways they use SNS. Whereas some only use them for communicating via chat and possibly receiving information, others actively create content to be seen by others.

> ***Case study 1.*** *Having previously found out that one of the teachers used SNS quite often, we viewed his Facebook profile. We discovered that 55 statuses had been placed in his profile in the last three months (not including possible comments under the status). Some of them were initiated by the teacher in question while others were posted on his wall by his friends.*

Although most teachers addressed in the study use SNS for personal reasons, we did meet a teacher who sees his SNS profile as a work-hobby one and claims not to publish any personal information: *"(...) I don't need to share any of my private life. I'm more into joining some discussions, those that I'm keen on or I'm interested in*". Apart from that, some teachers use alternative SNS, which help them with their hobby (for example, the travel site Couchsurfing.com).

Privacy. Teachers usually try to protect their privacy on SNS. Some decided not to publish details of their private life via statuses, not even for their circle of friends. This is illustrated in the following quote: "*If I want people to know my current status, I tell them in person or I call them. Or I send a text message. Or I write it in a chat message. But I don't have to post it on the wall*". However, some of these teachers are willing to publish information on SNS provided they regard it as not being of a personal nature: "*I don't see anything wrong in that, because I think that's information which, if someone asked me, I would definitely tell him*".

> ***Case study 2.*** *An interesting approach was encountered here – publishing messages on SNS in the form of allegories. As the teacher in question stated, although these messages can be seen by all friends, only close friends should be able to determine their real sense. People who the teacher does not keep in close contact with (the teacher's pupils in this case) can only understand such a message at a superficial level and privacy is preserved.*

Other teachers do not object to publishing private information, but they do insist on such information being carefully selected and rights for chosen people being strictly set – an example being one of the teachers' statements: "*You can show them what's new but I would also insist* *on everything being as it ought to so that no stranger can see it, so that no one can get to it*". Moreover, we have even encountered the case of a teacher who is not concerned about posting details of his private life within his circle of friends on SNS: "*Sometimes I boast with my current status, when I get really angry and want to scream out loud to the world. Or with my status in the morning, if it is funny*".

> ***Case study 3.*** *During our investigation we found a business card photograph in one of the teachers' Facebook profile accessible to the public. The photograph portrayed the teacher in question with his dog and his car was standing in the background with a clearly visible registration number. Apart from the teacher's full name and nickname, his address and mobile phone number had been inserted into the photograph. Other photographs also contained information about the teacher's private life (his interest in cycling, ownership of a certain breed of dog, and car registration number). Having expressed during the interview that he did protect his privacy, we confronted this teacher with the above mentioned findings. He was surprised, explaining that access settings for the photos must have been wrong and claiming that he knew nothing of the problem (the photographs had been posted on his profile for around two years). After being informed, he removed the business card photograph from his profile.*

Handling photographs. Teachers' perception of publishing photographs on SNS varies. Some of them refuse to post photos on their profile whilst others do not disapprove of posting photos for their circle of friends: "*So you're on holiday, you seem to have a few decent photos, even without any people, so you post them, so people can take a look at them*". Some consider the Facebook option of labelling a certain person in a photo as a threat to privacy, because such photographs are made accessible to friends of the labelled person: "*I don't like those third party rights to mark people on photographs. That really gets to me*".

> ***Case study 4.*** *During our study we encountered a teacher who posts photos of himself having fun with friends at parties. When asked how he perceives these photos, he replied: "A photo of me holding a drink somewhere with someone doesn't matter. But if it were a photo which could ruin my personal or professional reputation in some way, then that would really get me".*

Some teachers place their photographs in specialised web photo galleries rather than publishing them on SNS. Some of them use passwords to prevent their photos from being accessed by unauthorised people: "*I use servers that specialise in storing photos and it's protected by password, it can only be accessed by people I give the password to*". Other teachers publish some of their photographs on web photo galleries without explicitly protecting them against possible access: "*(...) otherwise, I'm more likely to give my friends a link to a web like rajče.net (...)*". It has to be said that even just being required to enter the right link to get to the photo gallery might be considered a certain form of security. However, the possibility of using a search engine to find a given photo gallery cannot be ruled out, even without knowing the exact URL address.

> ***Case study 5.*** *During our investigation, we encountered a teacher who posts documentary photo albums from his holiday travels on Google+, whilst also having a link to them on his own website. When questioned as to whether he perceived this*

a privacy risk, he replied that he didn't as "(...) these are explicitly things that are public and I'm making it available to anybody at all, whoever is interested. I am occasionally approached by people who have Googled me or maybe Googled something about a place I know and I'm able to advise him (...)".

Befriending pupils. Befriending pupils on SNS is a current and sometimes controversial issue for a number of teachers, but there are great differences in teacher behaviour. Some teachers strongly reject being friends with pupils, as seen in the following quote: "*I would rather not accept pupils as Facebook friends and I think it would be good if all teachers were of that opinion and rejected them*". Others do not disapprove of such behaviour or do actually befriend their pupils under certain conditions. The most common requirement is not to reveal one's private life to pupils. To achieve this aim, he might make efforts not to open up his private life (as discussed above) or to separate his virtual friends into certain groups with restricted access to each group's posts: "*(...) I think I have a hierarchy in my posts so what I don't want them (pupils) to see is restricted to certain groups (...)*". During our study, we encountered a teacher who opens up his private life to pupils on SNS, as documented by Case study 6.

Case study 6. *During our study, we encountered a teacher who accepts pupils as Facebook friends, even publishing posts of a personal nature (see Case study 4). He claims not to have changed his behaviour on Facebook because of his pupils. When questioned as to how pupils reacted to these posts, he replied: "The statuses were (for them) attractive and they didn't make anything of it, just making fun of it, making light of it, so it didn't go any further, as far as school is concerned and so on, it was just between us. Or, should I say, those who had seen it all. (...)*".

A number of teachers befriend their former pupils via SNS, as documented by the following quote: "*I have a rule not to add the person concerned if he were my student, but as soon as he ceased to be my student and sent a friend request, I would accept him*".

Cancelling unused accounts. Some teachers try to cancel social network site and community server accounts which they no longer use, due to efforts to control personal information that has been online and to remove traces of any previous activity. One of the teachers accounted: "*I know there can still be something from the past even though I have tried to cancel accounts on sites like Spolužáci.cz and other similar ones. (...) And I don't want anyone to access this information about me*".

Case study 7. *During our investigation, we found a nickname on one of the teacher's Facebook profiles. Using this name in a Google search, we found the given teacher's profile on a certain dating portal with a number of personal details and photographs. This case demonstrates how suitable it is to do an information audit and discover what information the Internet holds on us and to reconsider the suitability of such personal details being online.*

Causes of behaviour on SNS

The Causes of behaviour on SNS category looks at the circumstances which influence teachers' decision making as regards whether and how to use SNS. This particularly concerns the benefits and risks of using SNS in the teacher's personal life, the possibilities of including SNS in their teaching and the teacher's approach.

Benefits of using SNS. One of the reasons for teachers using SNS is the possibility of private communication, particularly with friends or relatives. SNS enable teachers to gain information about people who they are not in contact with: "*If I haven't heard from someone for a long time, I have a look at his profile to see if he's written anything interesting about himself*". This approach is used by some teachers to find out about their former pupils: "*I know where they (my former pupils) are and if they have children, I know what their kids look like and that kind of thing. It's like a never-ending reunion. (...)*". Teachers also use SNS as a source of entertainment or interesting information: "*I often get involved in discussions around here and that sort of thing. Cause people post interesting materials there (...)*".

Risks of using SNS. Some of the teachers (without regard to whether they use SNS) are concerned about the security risks associated with using SNS. These include the risk of insecure data protection from intruders (from other users and hackers), the risk of identity theft or the use of fictive identities. Teachers are also concerned about the abuse of posted data: "*I think you have to accept the risk of having any of the information you post used against you*" and about their privacy: "*I don't want strangers to look into my private life (...) I might have some kind of phobia but I don't want just anyone to be able to find me and see what I look like, what my name is, where I live or what my house looks like. I simply don't want that*". The above mentioned fears are multiplied due to the teacher's position and some teachers are anxious about their pupils accessing their private content: "*I think they (pupils) could get to it (my private photos). Because I wouldn't post it there but a friend of my friend and his friend might*".

Scepticism towards SNS. Teachers who do not use SNS argue that they are not really interested in this service: "*I don't need to present myself on the Internet. If somebody needs to, why not…*". Some teachers are extremely sceptical towards SNS, though, arguing that so much time can be wasted on them: "*The point is these kids spend so much time on Facebook … I think it's a waste of time and if I think so, I won't be using it*". We also recorded opinions criticizing the impersonal nature of SNS, superficial communication, lack of cooperation and the spreading of untruth and rumours among users. One teacher remarked: "*I don't think these social network sites actually meet up to what they were originally set out for – for cooperation. If you have a look at these social network sites, what's going on there, they (users) are just chatting there (...)*".

Including SNS in teaching. Teachers have great differences of opinion on the use of SNS in the classroom. Some of them don't expect to use SNS in the classroom: "*As a teacher, I see my students every week, so I don't need it (a social network site)*". Others regard SNS as a communication tool, enabling them to be accessed by their pupils: "*(Pupils) asked me about something like regarding a test, that they're writing a test after the weekend, so they asked for details (...)*" or "*It mainly served for communication, like a note from a pupil saying he's going to be absent the next day (...)*".

Teacher's approach. To ensure professionalism, teachers adapt their behaviour on SNS (particularly with regard to teachers befriending pupils). Some teachers try to keep a certain distance from pupils in fear of losing authority: "*If a student sees those photos of yours there* *or if he can comment on something about you, then let's say that gap disappears, it's completely wiped out*" or in an effort to keep work and private life separate: "*I don't think I need to chat with them in my free time. My job is to teach here, so I teach, but it's still only a job (...)*". We have recorded a contrasting opinion, though, where the teacher tried to get as close as possible to his pupils via SNS: "*I like talking to them (to pupils), I want to find out how today's teenagers behave, how they think. So (I try) to get in among them. It's my kind of teacher strategy*".

Some teachers' awareness of their role as educator is evident from their view of pupils' profiles. They are aware that by accepting pupils as friends they would begin to have more direct access to the content of their profiles with all the various statuses. Some of them are concerned about this situation because of the possible presence of unsuitable statuses, which they would have to respond to as teachers: "*He might have something written on Facebook, so if I responded to it in some way, he would unfriend me and it's as if I had never befriended him but if I didn't respond to it, I don't think it's quite in accordance with who a teacher is. Because a teacher should be involved in his pupils' upbringing*". Other teachers do not find this situation troubling and believe pupils would soon adapt their profiles: "*Students who befriend teachers realise they are under control. That someone will later see their posts (...)*". During our study, we encountered the case of a teacher who discovered unacceptable statuses on some of his pupils' profiles, as shown in Case study 8.

> ***Case study 8.*** *During our investigation, we met a teacher who befriended pupils from his class on Facebook. As the teacher confessed, after some time, some of his pupils started to post statuses with inappropriate content: "(...) despite knowing we were friends, they wrote stuff they might have known or, more to the point, I think they knew I would disapprove of, particularly concerning school, and they planned various things like what will happen in the mountains (...) and whatever else". Finding this a serious matter, the teacher refused to ignore it, which turned these pupils against him. He decided to unfriend most of the pupils. In his statement, the teacher told of this matter dividing the class into two groups – those who accepted his approach and the rest who began to behave "brutally". When asked to review this matter, he said: "I'm really glad I had such an experience and I think it's a good thing because (...) at least I know what can happen and I've simply learnt a lesson to watch out who, as far as pupils are concerned, I make friends with".*

Interest in new trends. The role of ICT teacher is evident in some teachers' efforts to keep themselves informed on the latest ICT trends. It might become the impulse to actually register themselves on SNS: "*The only reason I tried Facebook was because I wanted to know, ... when I started teaching Informatics a few years ago, so I knew what it involved. I didn't really catch on, though (...)*".

Evaluating others

The Evaluating others category concerns teachers' opinions on other people's use of SNS. Teachers gave their evaluation spontaneously to explain their attitude to a certain issue in more detail. As they usually restrict their own behaviour according to other people's, they mostly criticise, rarely agreeing with other people's behaviour.

Intensity of SNS use. Some teachers are critical of the intensity of social network site use by other people, particularly pupils: "*When I started teaching at the lower secondary, the students were capable of spending all their free time on Facebook. Which is really frightening (...)*". There was no positive evaluation of the intensity of SNS use by others.

Privacy. Teachers mostly criticise the ways other people protect their privacy. While some of them criticise their pupils' improper habits: "*I have a few kids from high school on my Friends list (on Facebook) (...) and these are blatantly expressive (...)*", others are critical of their real friends' behaviour: "*I have a friend and every time she goes on holiday, she rushes headlong into posting all 200 of her seaside holiday photos on Facebook the day after she gets back. She's a real stunner, by the way. I would say she's really stupid (...)*". There was only one positive evaluation of other people's privacy protection, the teacher quoting his wife as an example of somebody who manages their personal details prudently.

Befriending pupils. As teachers do not have a unanimous opinion on the issue of befriending pupils, their evaluation of others also varies in respect to this. We thus encountered criticism of colleagues and pupils for befriending each other: "*I know there are students like that at our school who friend request some teachers and the teachers accept. Or it might even be the other way round. I find it a bit alarming (...)*". On the contrary, one of the teachers (who does not personally oppose befriending pupils) indirectly encouraged his colleague's similar behaviour: "*One colleague from lower secondary has a motto, which I really like, saying: »I do not accept requests from under-15s, only in virtuous exceptions « (...)*".

Conclusion

Our study has led us to discover how teachers behave in social network site environments and what motives lead to such behaviour. Teachers particularly appreciate SNS because of the possibility to communicate and keep in touch with people they know, including former pupils. Teachers are concerned about the risks associated with using SNS, particularly security and privacy risks, and they feel even more under threat due to their occupation. Some teachers decided not to reject their pupils' friend requests for educational reasons, claiming SNS serve as a channel of communication to support teaching and learning. Our study has found that teacher-pupil connections on SNS do not necessarily mean teachers inappropriately reveal their private lives – some teachers use their profiles for work only or at least do not present any personal details.

Further research should focus on how a teacher's knowledge and attitudes regarding online privacy protection influence his teaching. One particularly important question seems to be how teachers with varying experience of using SNS build pupils' knowledge that will protect them from the risks of using SNS.

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LET'S PLAY: THE GAMIFICATION

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Imagine the following situation: You are in a shop. You pay a whole purchase. A saleswoman gives you a card with benefit points. After week you return and make another purchase. You get more benefit points and some small discount. You return to the same shop because your benefit is increasing with every purchase even the small one. What is more You are enjoying it. You play the game. You have been gamified.

Previous example shows us one of many gamification principles. We are part of gamified environments every day even though we might not realize it. However, the study of gamification and its mechanics is not a new phenomenon. It has found its place across many professional fields e.g. marketing or sales. Sometimes the gamified elements are hidden but usually they are visible at first sight. More frequently we have just accepted them naturally as a part of certain environment. These elements can easily take a lot of different forms. In the example we use benefit points, but we could also imagine customer vouchers, discounts, badges, various little gifts etc. We tend to no more distinguish between those. As a counterpart are visible elements. In the Fig there is shown the use of gamification in the internet banking information system.

Fig. 1: The Internet Banking Gamification

Through the means of badges, the bank tries to motivate internet banking users to use it more. It also tries to teach them how to use internet banking or how to customize it for their own needs. Those simple additions to the classic internet banking environment are trying to change it into more friendly and positive user experience every time they use it. The bank does this on purpose. If user is satisfied, he or she is going to use internet banking more frequently. This can mean more transactions which can generate a profit.

The gamification itself works with motivation. In the psychology field the theory is called incentive motivation. It can take two forms: the intrinsic (inner or internal) and extrinsic (external) motivation. First motivation is described as being held deep in ourselves and it helps us doing things with ease. Inner motivation usually takes a big part when we are playing something. Because if we are playing and we like it that often means our inner motivation is boosted. We do some activity because we like it and not because we have to do it. We want to spend time doing it so for the simple pleasant feeling. On the other side there is external motivation. We do some activity because in the end we get some kind of reward. The reason why we do it even though we dislike the activity is the vision of that reward and this helps us to overcome often repetitive boring quests or duties. The gamified environment brings also positive emotions and better productivity, because if you do not feel you are working you do not take the activity as an unpleasant matter (and work has for many people negative connotation) (Kapp, 2012).

If all that is presented as the positive aspects, there should be also some negative ones. Indeed, psychologist often show negative impact mostly in the form of dependence. All Facebook users know the “Like Button”. Its origin purpose was to show positive response to some element on the stream wall like photo, video or status. But we can easily come down to “Likes Hunt” when we are trying to achieve as much as possible likes we can. Then we can compare or even compete with others and original meaning of the “Like” itself is lost. In the shops the owners are trying to develop dependence in you – to their store. By giving you the benefit points, vouchers or gifts you are being more and more attached to that specific store or store chain.

Gamification Theories

However, the gamification can be used in the education environment too. It can play an important role to help students overcome learning motivation problems. In the recent years the scientific papers start to focus on the use of gamification aspects in education more (Library Technology Reports, 2015b). Although a plenty of theoretical papers were published, the experimental ones are still in the minority. But the topic is getting increasing attention (Dicheva et. al., 2015).

Despite this there is not yet established general terminology. Usually common agreement can be found in distinction between terms “Gamification Design Principles” and “Game Mechanics” (Kapp, 2012). The definition says that game mechanics are used to implement gamification design principles. We can elaborate this on an example. One of design principles is called “Freedom to Fail.” It means that students are not penalized for unsuccessful attempts. Even if they fail repeatedly they are allowed to repeat the activity until they succeed. This already works with motivation because students are not scared of failure – there is no limit (typically you can take test one, retake does not eliminate previous failed attempt), which makes them feel comfortable and not stressed (Library Technology Reports, 2015a, Chou, 2015).

In general, these ten game design principles are distinguished (Dicheva et. al., 2015):

- Goals/Challenges
- Personalization
- Rapid Feedback
- Visible Status
- Unlocking Content
- Freedom of Choice
- Storyline
- Onboarding
- Time Restriction
- Social Engagement

To implement those principles common game mechanics like “Points”, “Badges”, “Levels”, “Leader Boards”, “Virtual Goods” and “Avatars” are used (Dicheva et. al., 2015, Chou, 2015).

Example of Gamified Application

Meanwhile scientists are researching the impact of gamification in the education the developers of educational applications started to use it in their own way (Library Technology Reports, 2015). For example, multiplatform application called Duolingo is using rich variety of gamified elements. The application’s main purpose is learning languages. It has millions of users who are enjoying the fresh concept of learning.

In the Fig. we can see intuitive user interface of Duolingo’s web version. It shows some gamification design principles like “Unlocking Content,” “Goals/Challenges” or “Social Engadgement.”

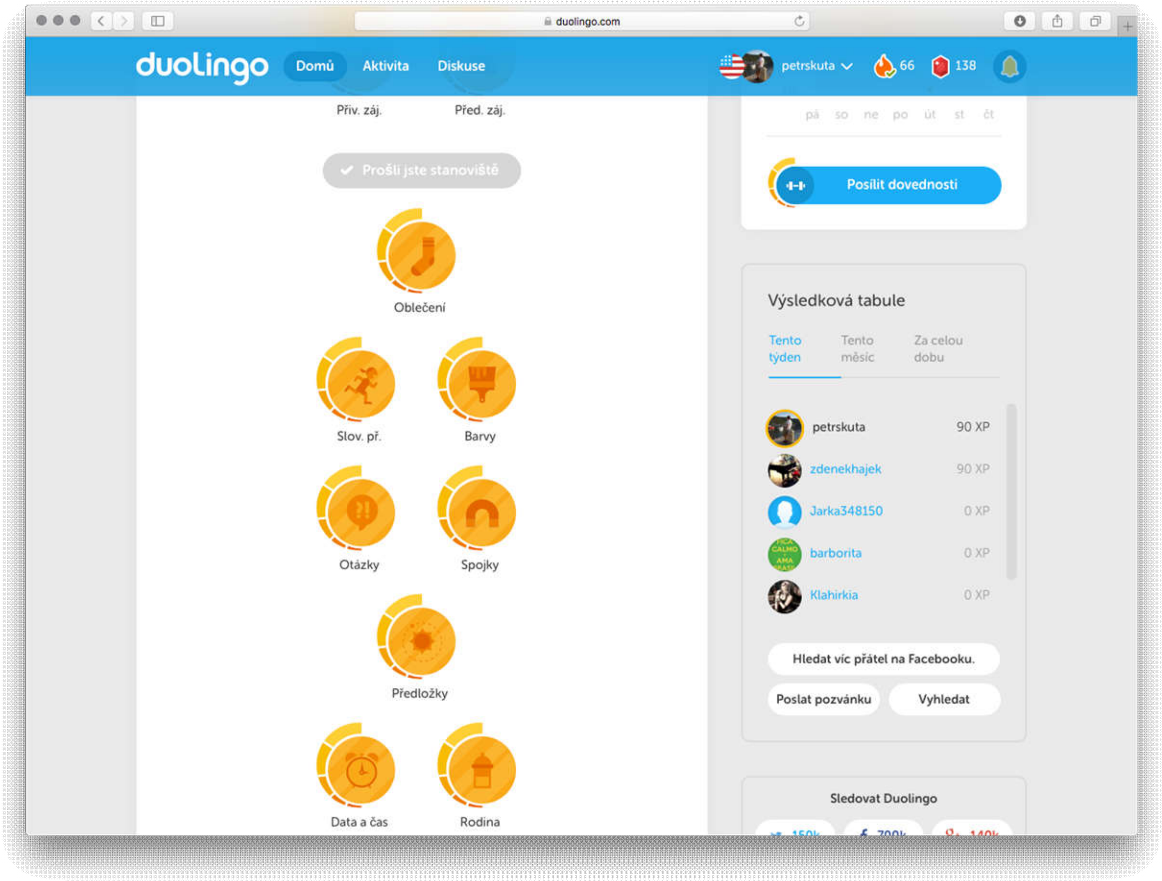

Fig. 2: The Gamified Education Application Duolingo

On the left side we can see individual lessons. These are represented by yellow badges each with status border – if it is gold it means the student has successfully passed the lesson. This is game design principle "Unlocking Content," because students have to do the lessons one after another to unlock them in the given order. On the right side we can see a leader board. There are nicknames of users, which are added by student itself. Mostly they are friends or they know each other. Through this leader board they can compare their progress in the week, month or year period. This is game design principle "Social Engagement" realized through "Leader Boards" game mechanic.

The student learning languages in Duolingo application is motivated by those elements and other game design principles and mechanics. They act positively on his motivation either inner or external. This leads that student is learning more and often he or she is enjoying the activity itself.

Conclusion

The gamification is not the new phenomenon. It is used in many fields and it is appearing in education environment recently. Motivation is one of the important aspects, which gamification works with. There has been published a lot of theoretical scientific papers on this matter, but no formal terminology has been agreed on. Gamification design principles are appearing in educational applications and one of representative of them is Duolingo. It successfully uses many gamification design principles and game mechanics to help learning languages.

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