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Dear Readers,

We would like to thank you for your patronage in 2016 and hope you will stay with us in 2017. On behalf of the entire editorial board, we promise to keep improving the Journal, thus making your papers available to a greater number of readers and researchers from all over the world.

As I mentioned in the last issue, the ICTE Journal is now published by De Gruyter, a professional publishing house. Moreover, it is also included in the following 17 databases:

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In 2017, you can look forward to a new, modern and fresh look of the Journal. Moreover, we will continue to pursue the inclusion of our journal in the SCOPUS database.

Mathematics is one of the subjects where ICT has been used to good effect. As far as mathematics is concerned, ICT is used not only for complex calculations, but also for simulations and graph plotting both at high schools and universities. The implementation of ICT into mathematics instruction can have a positive impact on students' motivation. The paper "Impact of Inquiry Approaches to Mathematics Teaching on the Development of Skills to Analyze and Interpret Relationships between Variables" deals with this issue.

In order for the implementation of ICT and e-learning in schools to be effective, it is necessary to focus on the ICT skills and competences of the teachers. The paper "Advantages and Barriers to the Introduction of E-learning Environment into Academic Teachers' Activities in Ukrainian universities" describes the situation at Ukrainian universities.

ICT can also be used to encourage a cross-curricular approach in instruction. The paper "Cross-curricular Approaches in Inquiry-Based Science Teaching" deals with a cross-curricular

approach in science courses. The use of this approach can increase the students' motivation and interest in science natural sciences.

The last paper in this issue, "Variant Texts According to Types of Sensory Perception", is devoted to the creation and evaluation of study materials according to the student's learning style (visual, auditive, kinaesthetic). Based on the students' learning styles, 4 versions (the final version being verbal) of study materials were created and assigned to 35 university students.

We hope that the aforementioned papers have not only caught your attention, but will also inspire you in your future endeavors. Finally, let me wish you a healthy, happy and successful 2017.

Tomas Javorcik

Executive Editor

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IMPACT OF INQUIRY APPROACHES TO MATHEMATICS TEACHING ON THE DEVELOPMENT OF SKILLS TO ANALYSE AND INTERPRET RELATIONSHIPS BETWEEN VARIABLES

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Abstract

The development of inquiry skills to analyse and interpret data from tables and graphs, identify, understand and use relationships between variables represents an important goal of mathematics teaching. Our research is currently focused on the development of high school students' inquiry skills in mathematics teaching and diagnosing the quality level of their acquisition. The first phase of the research was oriented on the development of innovative methodical and learning materials based on inquiry approaches to mathematics teaching. In the paper, we present interactive learning activities implemented in the system Geogebra, which enable students to analyse graphs of functions, formulate and test hypotheses, express relationships between variables and generalize mathematical findings. As a part of our research we conducted a pedagogical experiment in six Slovak high schools focused on application of inquiry approaches to mathematics teaching. The main purpose of the pedagogical experiment was to assess the effectiveness of inquiry-based mathematics teaching in the development of inquiry skills to analyse and interpret relationships between variables. The levels of the development of the inquiry skills were diagnosed using pre-test and post-test. The pre-test was answered by 332 students from 1st or 2nd grade groups (fifteen and sixteen year old students) of six high schools. The post-test has been given to the same groups after applying innovative teaching methods based on the inquiry approaches to learning. The post-test was answered by 288 students. The basis of quantitative analysis of the test results was a statistical testing of the hypotheses that our innovative teaching method induces a significant improvement in selected inquiry skills.

Keywords

Mathematics teaching, inquiry skills, interactive learning activities, pedagogical experiment, pre-test, post-test.

Introduction

Sciences, mathematics and technical disciplines have key importance for the continuing acceleration of scientific and technical development of the society. Despite the importance of these disciplines for the development of society interest of young people in learning mathematics and science falls and the number of students that wish to study science and technical universities decreases. Many studies have highlighted an alarming decline in young people's interest for learning of science, mathematics and informatics. A reversal of school practice from mainly deductive to inquiry-based methods provides the means to increase students' interest in science and mathematics [Rocard, 2007]. Inquiry-based teaching encourages curiosity and observations followed by experimentation, modelling, problem solving, explanation and justification of findings. Previous research has shown that inquiry-based mathematics teaching enhances students' understanding, mathematical thinking and problem-solving skills [Hähkiöniemi, 2013].

Teachers should try to find ways to enhance students' motivation, to make the education process closer to real life and to more excessively connect teaching of mathematics, physics and informatics. One of the ways to innovate the educational process is the application of inquiry approaches to teaching. Inquiry in education is, just like scientific research, aimed to ask questions, to find and justify answers. Inquiry-based teaching offers a potential for developing the students' inquiry skills. Young people should acquire skills to gather and analyse data, interpret results, conclude, justify and generalize conclusions in mathematics and science teaching.

The official documents characterizing the strategy of mathematics education in the European Union (Eurydice, 2011) emphasizes the importance of the development of mathematical and digital competencies for a full and active integration of young people in the modern knowledge society. ICT can play an important role in creating learning environment supporting students' inquiry and raising their motivation. They allow creation of an experimental, interactive and dynamic environment stimulating active learning. Successful integration of ICT into mathematics teaching requires a development of learning activities for students and various supports for teachers. In our experiment, we primarily used the dynamic geometric system Geogebra to create interactive learning activities for investigation of functional dependencies between quantities. Geogebra integrates algebraic and geometric tools and it brings new means to visualize and investigate mathematical structures and relationships in mathematics teaching [Hohenwarter, 2007]. Geogebra can help students to explore, conjecture, construct and explain mathematical relationships. It allows generating appropriate examples and counterexamples from which students can be asked to detect patterns, make conjectures, and develop arguments [Davis, Fonger, 2015].

Selected results of international testing mathematical literacy

Results of several international examinations show a decreasing level of mathematical literacy of students not only in Slovakia. In recent years, student achievement in mathematics is assessed through two large international surveys, namely TIMSS and PISA. The TIMSS 2011 [Galádová, 2015] study involved more than 65 countries worldwide. The results of the assessment offer a

complex view of the learning outcomes of students in the fourth grade of elementary schools in reading literacy, mathematics and science. To illustrate this we chose a task involved identifying the relationships between data displayed in a graph.

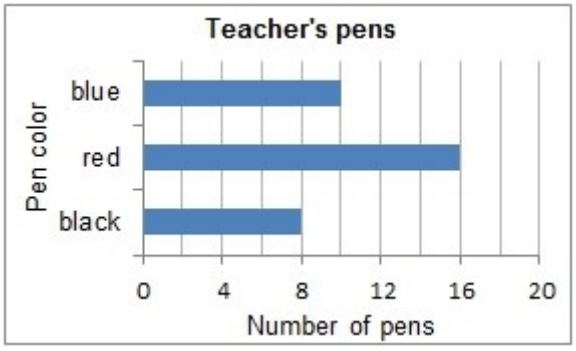

Fig. 1: Interpretation of relationships between data in the graph

The graph shows the amount of blue, red and black pens that the teacher has on his desk. How much is more red pens than black pens?

The problem was correctly solved by 45,4% of Slovak students on average. The achieved result falls considerably behind the average result of the OECD countries which is 61,7%.

The international OECD PISA study focuses on measuring and comparing learning results of 15 years old students of the respective schools in reading, mathematical and scientific literacy. In year 2012 the examination was oriented to mathematical literacy, and the main focus was on testing the ability to solve problems and on financial literacy [NÚCEM, 2013]. To illustrate the application of graphic representation of data in examining the relationships between data we chose a part of the exercise "charts". New CDs by bands 4U2Rock and The Kicking Kangaroos were released in January. They were followed in February by CDs by bands No One's Darling and The Metalfolkies. The provided graph depicts the sales of the CDs of the respective bands from January through June. The Kicking Kangaroos' manager is worried, because the number of sold CDs has been decreasing from February to June. What will be the approximate sales volumes in July if the same negative trend will continue?

A) 70 CDs B) 370 CDs C) 670 CDs D) 1340 CDs

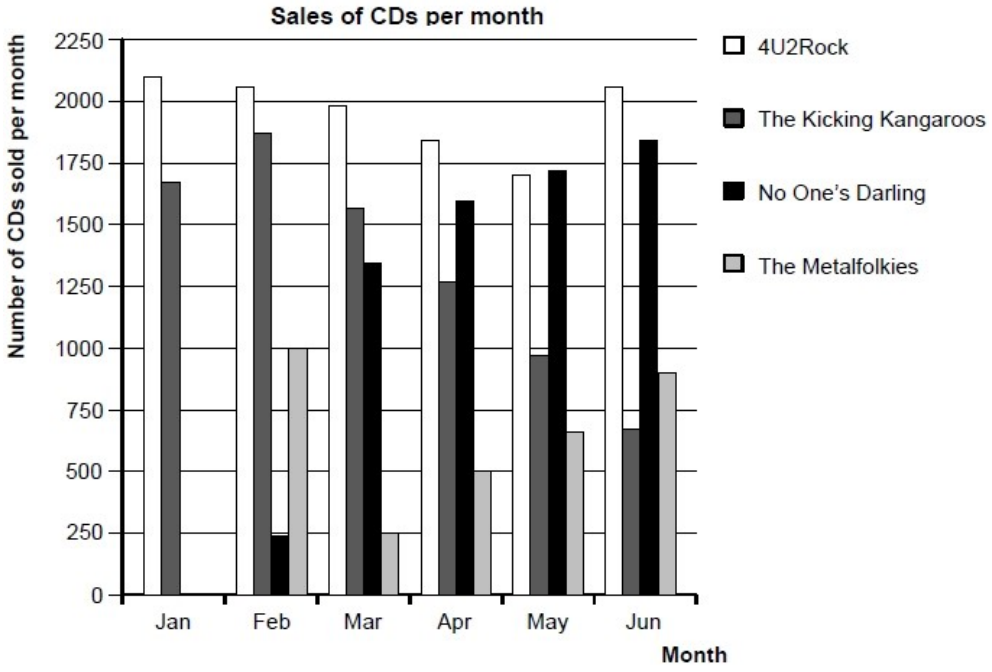

Fig. 2: Sales of CDs during the reporting period

The correct answer is 370 CDs. The average percentage value of correct answers by Slovak students was 68,5%. It is also another case in which the results fall behind the results of other countries, since the average success of the students from OECD countries was 76,7%.

The project focused on assessment of the effectiveness of inquiry-based teaching

Efforts to implement inquiry approaches to science and mathematics education are reflected in the wide range of projects supported at the level of the European Commission or by national research agencies. Researchers at our faculty participated in solving international project ESTABLISH and SAILS. The results and experience of dealing with these projects are used in the project supported by the Agency for the promotion of research and development which is aimed at the research on the efficiency of innovative teaching methods in mathematics, physics and informatics education. The main goal of the project is assessment of the impact of inquiry-based teaching on the development of students' inquiry skills. Two hypotheses were defined according to the specified goals. A natural pedagogical experiment was used for the verification of hypotheses. The main focus was concentrated on the assessment of inquiry-based teaching impact only in selected groups in high schools. The first phase of the project solving was focused on designing and developing innovative lesson plans and teaching materials for applying inquiry approaches to the teaching of mathematics, physics and informatics at high school. According to the study of school education programs, we selected topics that were corresponded to the planned timetable of the experiment.

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 account in designing lesson plans enabling the application of inquiry approaches to

teaching mathematics. An important part of the development of innovative learning materials for inquiry-based teaching was a preparation of interactive learning activities. In the article, we focus on a description of selected inquiry activities for exploring relationships between variables and the use of functional dependencies for problem solving. Interactive activities created using Geogebra support students to explore graphs of functions, to make and understand connections between representations, construct hypotheses, and explain observed patterns. Linking various representations is an important domain in the understanding of function [Ronda, 2015]. Progression involving linking representations can begin in working with linear functions, when students can first make connections between a graphical and verbal representation and then connections between graphical and symbolic representation. Each of the three representations can highlight a particular property of the relationship between variables. We chose an activity based on real situation: *A litre of gasoline is sold for 1,58 EUR in town A. A litre of gasoline of the same kind is sold for just 1,28 EUR in town B which is 30 km away from town A. It is worth to a man living in the town A go to refuel in the town B if their car has an average gas consumption of 6 litres per 100 km?*

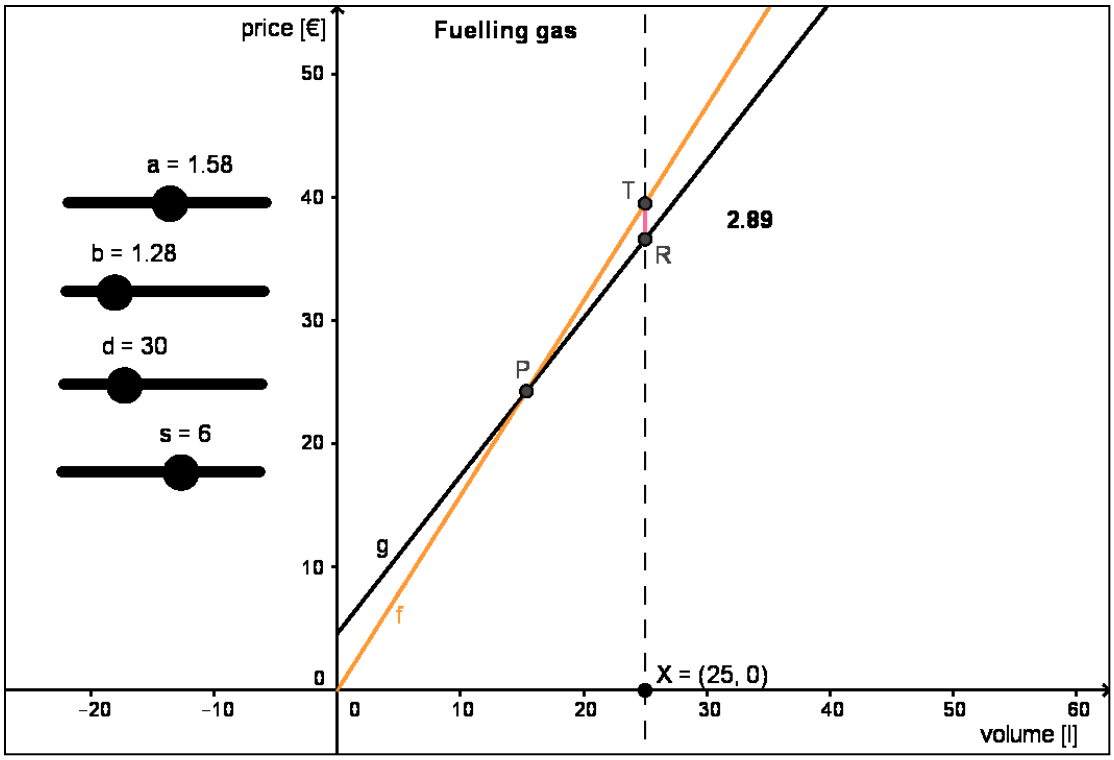

Fig. 3: Graphical model of a real situation

Students should first create a table and a graph describing the price for refuelling in the town A. Then they should decide how the graph of explored dependency would change, if the driver refuels gasoline in the town B, while considering the lower gasoline price in calculation of the price for the travel to the town B. The students would be given the dynamic construction displayed in figure 1 only after understanding the described situation. Then they would solve the following tasks:

1. Describe verbally the functional dependencies represented by graphs of functions f, g.

2. Characterize the meaning of the intersection of graphs of functions f, g.

3. Find out the lowest amount of litres of gasoline which should the driver refuel in the town B so as to be worth it if the price for the gasoline in the town B dropped to 1,20 EUR.

4. Characterize the meaning of the number displayed in the graphic window to the right of the graph (by changing the position of the point X).

5. Describe the effect of individual variables on the amount of saving for refuelling in the town B.

6. Use function formulas for f, g to express the amount of saving for refuelling in the town B.

Solved task was focused on the calculation of the price of gasoline consumed by moving car. Motion tasks may be appropriate used to investigate the dependencies between variables, for example the relationships between the moved distance or the speed of objects and the time.

The applet http://demonstrations.wolfram.com/FillingAContainerDefinedByACurve/ offers interesting theme to model the dependencies between variables. The applet is located on the portal demonstrations.wolfram.com by the company Wolfram Research, which offers a variety of interactive demonstrations useful in the teaching of mathematics and science. Start-up of interactive demonstrations requires installing the free available program Wolfram CDF Player.

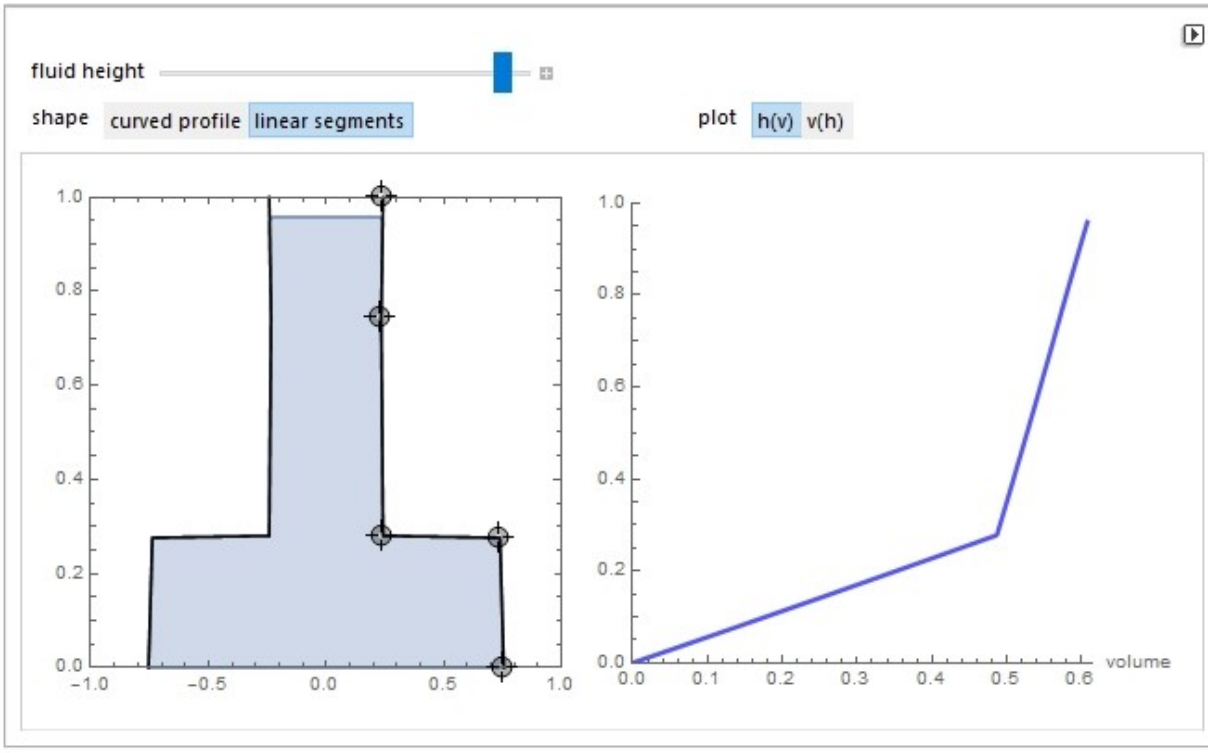

Fig. 4: Modelling the dependence between quantities

The described applet allows modelling uniform filling water into containers of various shapes and simultaneous construction of a graph of the dependence between water level and the volume of water in a container. Since the water flows uniformly into the container, investigated dependence can be interpreted also as the dependence of the water level height on the time. The shape of the container can be modelled by straight lines or with curves. The container in figure

4 is made up of two cylinders with different diameters. The graph shown at right has been built over the simulation run.

At the beginning, the teacher should explain to students in classroom described phenomenon using the example of dependence between the water level height and the volume of water for the container of cylindrical shape. The teacher should require students' predictions about the character of a graph showing the investigated dependence. The use of interactive demonstration would only follow after explanations of arguments to justify the shape of the graph. Then the teacher would ask the students to justify shapes of graphs for cylindrical containers with different diameters and for the container shown in figure 4. Investigation of more difficult dependencies for containers with more complicated shapes could follow in the next phase of teaching. Students could solve the problem: what shape should have a container in order to a graph of the dependence between the water level height and the volume of water increases faster than a linear function. One of the possible solutions is shown in figure 5.

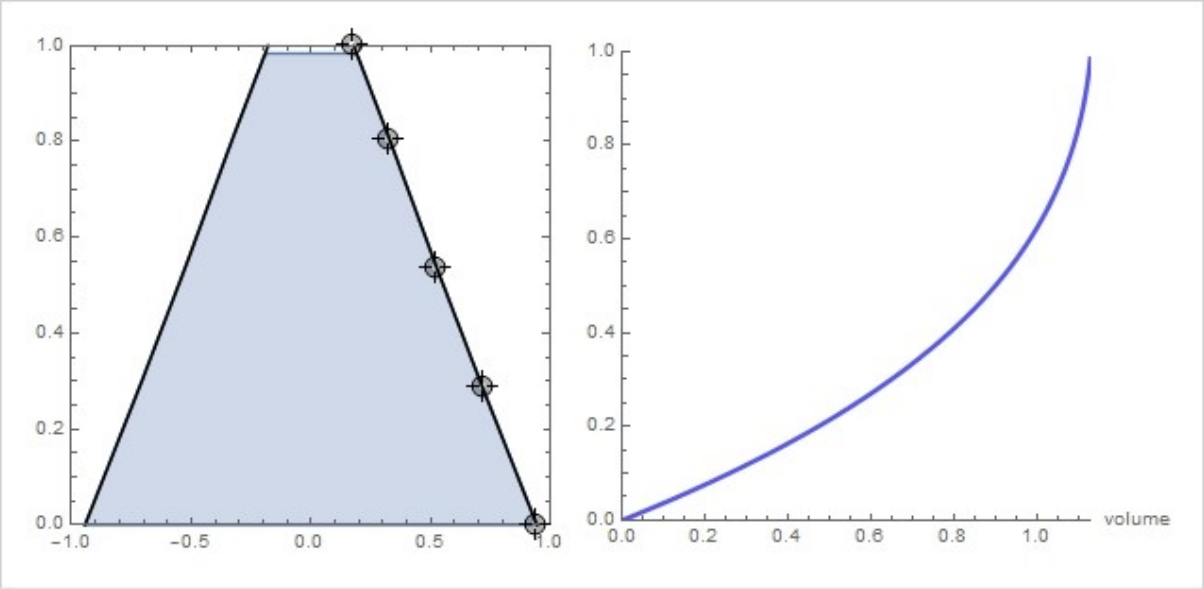

Fig. 5: Modelling of a nonlinear dependence between quantities

Since the diameter of the container is gradually reduced water level height will still grow at greater values, not at the same values as by the linear function. Finally, students could construct graphs of the dependence between water level height and the volume of water in a container for different shapes of containers on paper that would show the teacher on the blackboard. Students should also solve the opposite task and they would suggest the shape of the container in accordance to given graph. Interactive demonstration can be used to confirm or refuse students' solutions.

Graphs of functions on six cards (see figure 6) was given the students in the activity focused on analysis of graphs of functions. Students should split cards to two groups with the same number of cards. After allocation of the graphs of functions using their symmetry with respect to the y-axis or to the beginning of the coordinate system, students are asked to find function formulas which graphs have one of listed properties. The students could use the system Geogebra for the construction and analysis of graphs of functions. The teacher should also require from students

the generalizations of their findings. For example, if students assign the quadratic function $y = x^2$ to functions whose graphs are symmetrical with respect to the y-axis then the teacher should lead students to conclusion that the functions which formulas can be expressed in the form $y = ax^2 + c$, where a, c are real numbers and $a \neq 0$, have required property.

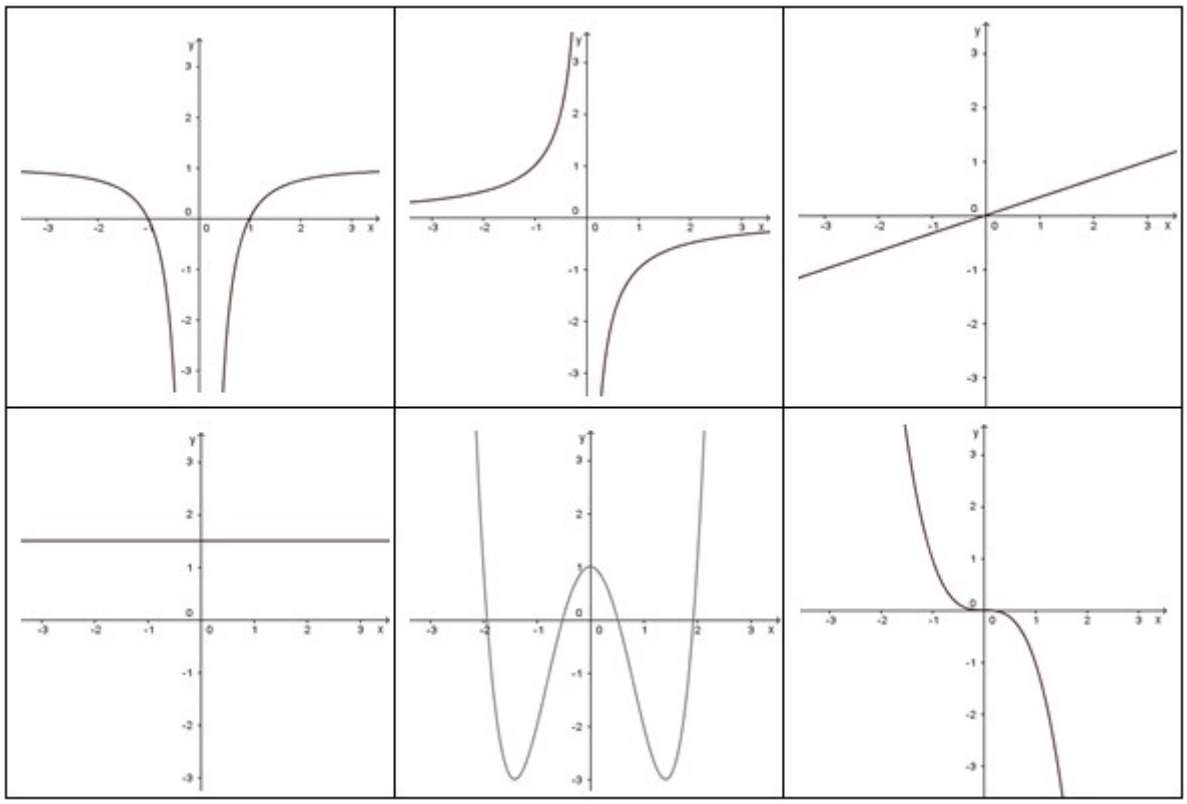

Fig. 6: Graphs of even and odd functions

The power function is convenient type of functions to investigate even and odd functions. Students should generalize claim about power functions in regard to parity of their exponent. Students should find out by the investigation of function properties that the classification of functions according to the parity is not dichotomous and there are functions which graphs do not have any of listed properties. Finally, the teacher could give students following activity for independent inquiry after introduction of the terms odd and even function: *There are certain rules for the sum or the product of two odd or even numbers. Investigate, whether the analogical rules hold for the sum or the product of two odd or even functions. Illustrate your findings with appropriate examples and find arguments to justify the discovered rules.* Students can simply construct graphs of sum and product of two functions and observe their properties using the system Geogebra. The definitions of the functions f, g in input line allow to get a graph of the function $h = f + g$ or $h = f \cdot g$ by writing of these formulas into the input line. Proving discovered findings should be based on the use of the definitions of even and odd function.

Testing a level of the development of selected inquiry skills

The created methodical and learning materials were tried in real school conditions at six partnership high schools. Experience and suggestions from the teachers were incorporated to

the learning materials. The final versions of the learning materials were used in pedagogical experiment conducted in the school year 2015/2016. Design of the experiment can be expressed using the following scheme [Reid, 2006].

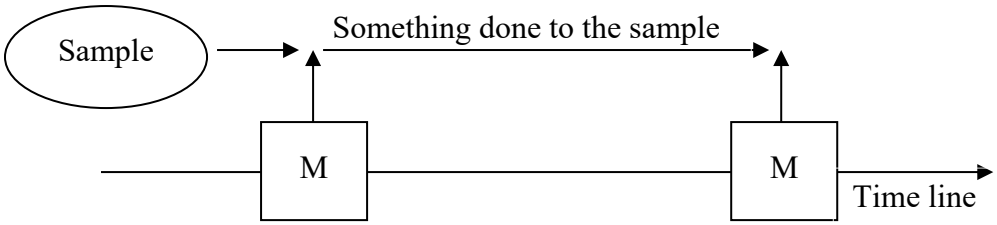

Fig. 7: Structure of the pedagogical experiment

The sample for the experimental teaching consisted of two chosen groups in the first and second class at the high schools. The teachers applied inquiry approaches to teaching of selected topics in mathematics, physics and informatics during October to March. The block in the scheme labelled as M represents a measurement with a test or a questionnaire. As an assessment instrument in the pedagogical experiment was selected a paper and pencil test to measure the level of development of inquiry skills of the students. The main goal of the pedagogical experiment was to evaluate the effect of the innovative methods of teaching on the development of selected inquiry skills of the students.

Two hypotheses were defined in the pedagogical experiment.

H1: Unsystematic and inconsistent use of inquiry approaches to teaching of mathematics, physics and informatics causes low level of the development of the selected inquiry skills of students in high schools.

H2: Systematic and coordinated use of the innovative teaching methods of mathematics, physics and informatics based on the application of inquiry approaches to teaching has a positive effect on the development of the selected inquiry skills of students.

50% performance success in the acquisition of standard knowledge and skills is often regarded as the limit of low level of success. To characterize a low level of development of inquiry skills we set the performance success of the students to 40%.

Several researchers have tried to develop assessment tools to measure students' inquiry skills. Alonso and Aschbacker [Lou et al., 2015] created a test for assessment of inquiry skills in the laboratory conditions in 2004. The test also contains various inquiry activities and requires students' experimental operations. Duration of the test was average of 2.5 hours. This was reason that the test was used mainly for research purposes. Orion and Kali [Lou et al., 2015] created the test developed within Earth science content for assessment of specific inquiry skills in 2005. The test contained twenty tasks in the multiple-choice form and it was suitable for use in the classrooms. Wenning [Wenning, 2007] created the test containing forty tasks in 2007. Each question included four options for answer of which only one option was correct. After the use of the test in real school conditions, the author admitted that closed tasks are not best suited for the measurement of specific inquiry skills.

Two measurements of the level of the selected inquiry skills development were planned in the pedagogical experiment (see figure 7). It was necessary to create the pre-test and the post-test for these measurements. Wenning's standardized test was our starting point for creation of the tests. The first phase of the pre-test development was focused on creating a database of mathematics, physics and informatics tasks suitable for measurement of the level of the selected inquiry skills. After selecting the inquiry skills which should have been primarily developed in the teaching of mathematics, physics and informatics, the first version of the pre-test was created and it was examined in three classrooms at three high schools. The final version of the pre-test was created after analysing the results of the trial run and taking into account the suggestions of the teachers which evaluated the difficulty of the tasks and suitability of the task for measurement of specific inquiry skills. Results of the pilot testing led to a reduction in the number of tasks in the pre-test. Whereas the priority requirements included the limitation of time to complete the pre-test for one lesson, the final version of the pre-test contained twelve tasks. The closed items in the pre-test included five options for answer among which two correct answers could be placed. Two semi-closed items required also reasoning answer choices. Two items of the pre-test were opened-ended. From the classification of the inquiry skills [Van den Berg, 2013], we focus on the evaluation of the development level of the inquiry skill to analyse and interpret the relationships between variables. We selected two tasks from the pre-test focused on testing the skill to interpret data from a graph (task 1) and to express the relationship between variables in the symbolic form (task 2).

Task 1: The presented graph displays the dependency of the distance that runners A, B ran in the race on the time. Based on the graph, decide which of the following statements is true.

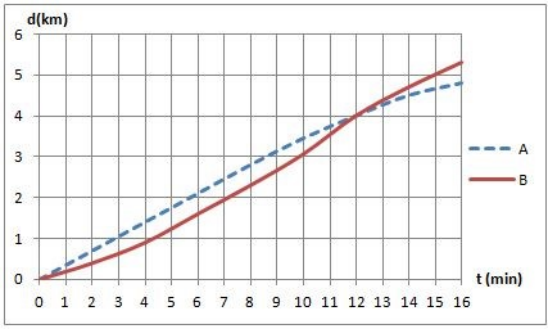

Fig. 8: Graph of dependence between variables

a) The runner B ran the first kilometre earlier.
b) The runner A ran for the first 10 minutes of more than 4 km.
c) The runner A caught up with the runner B 4 km from the start.
d) The runner A had higher average speed than the runner B during the first 16 minutes.
e) The runner B was running faster than the runner A since the end of the 10th minute until the end of the 11th minute.

The correct answer in the task 1 is the option e).

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

The task 2 has two correct answers expressed in the options b) and e).

The students in the experimental groups were given a post-test to measure the level of the development of the selected inquiry skills at the end of the pedagogical experiment. When creating the post-test, we considered two variants. The first variant involved including equivalent tasks containing different numbers which would base on the same or very similar context. The second variant involved including tasks based on the description of different situations. The deciding factors in choosing a variant of the post-test were fairly long period between the pre-test and the post-test (6 months) and a problematic comparing of the difficulty of the tasks. We decided for the first variant and we included only slightly modified tasks in the post-test. The following tasks in the post-test corresponding with the tasks selected from the pre-test:

Task 1*: The presented graph displays the dependency of the distance that runners A, B ran in the race on the time. Based on the graph, decide which of the following statements is true.

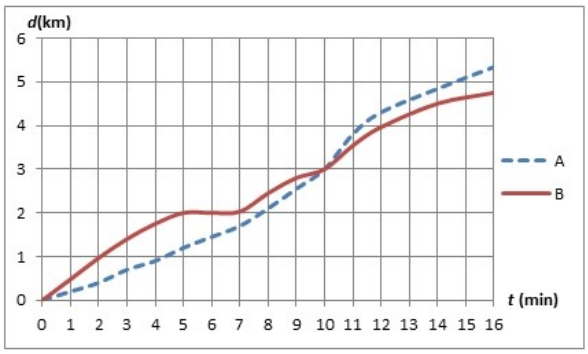

Fig. 9: Graph of dependence between variables

a) The runner B was running faster than runner A since the end of the 8th minute until the end of the 10th minute.
b) Both runners had during the first 16 minutes at least one minute break, when they were resting.
c) The runner B caught up with the runner A 3 km from the start.
d) The runner A had higher average speed than the runner B during the first 12 minutes.
e) None of the previous statements is true.

The correct answer in the task 1 is the option d). The assessment of the solution of the tasks 1 and 1* was binary. Student's percentage of achievement could be 0% or 100%.

Task 2*: Camila goes to a gym, in which one session costs 4 €. Since she exercises regularly, she paid a membership fee of 50 €, that allows her to get 50% discount for 30 sessions in the gym before the end of the year. Let x be the number of sessions, that Camila attended in the gym before the end of the year. Which of the following equations can be used to express the total sum s for sessions in the gym before the end of the year, if we know that Camila attended more than 30 sessions before the end of the year?

a) $s = 4x - 0{,}5 \cdot 4 \cdot 30 + 50$

b) $s = 4x - 0{,}5 \cdot 30x + 50$

c) $s = 4x - 0{,}5 \cdot 30x$

d) $s = 0{,}5 \cdot 4 \cdot 30 + 4(x - 30) + 50$

e) $s = 0{,}5 \cdot 4x + 50$

The task 2 has two correct answers expressed in the options a) and d). When evaluating the results of tasks 2, 2*, student's success was 100% only in the case if the student chose only two answers and both answers were correct. If the student is chosen only one correct answer his percentage of achievement is 50%. If the student is chosen the right answer in combination with the wrong answer his/her percentage of achievement is 0%.

Results and Discussion

Fourteen groups of the first and second classes in partnership high schools were participated in the pedagogical experiment. The average achievement levels of individual groups (signs of schools are stated in brackets) in the presented tasks are given in the table 1.

Group	Class	Specialization	Pre-test			Post-test		
			Count	1	2	Count	1*	2*
Kvinta (A)	1	M	27	55,56%	44,44%	26	57,69%	53,85%
1.A (J)	1	G	29	44,83%	36,21%	27	55,56%	37,04%
2.NB (O)	1	B	24	29,20%	25%	15	13,33%	30%
1.C (P)	1	L	30	36,67%	31,67%	25	24%	36%
1.A (S)	1	G	24	16,67%	18,75%	19	31,58%	36,84%
2.E (T)	1	B	24	41,67%	41,67%	22	22,73%	45,45%
Sexta A (A)	2	M	15	46,67%	50%	14	50%	57,14%
Sexta B (A)	2	M	22	36,36%	38,64%	18	27,78%	36,11%
2.D (J)	2	G	32	37,50%	34,38%	31	48,39%	41,94%
3.NB (O)	2	B	12	16,67%	25%	10	10%	20%
2.D (P)	2	G	30	36,67%	43,33%	27	29,63%	42,59%
2.B (S)	2	G	19	42,11%	34,21%	16	100%	50%
2.C (S)	2	G/L	26	15,38%	36,54%	24	25%	43,75%
2.C (T)	2	G	18	27,78%	27,78%	14	35,71%	46,43%

Tab. 1: Summary results of the pedagogical experiment

Groups are differentiated by class and specialization: G – general, M – mathematical, B – bilingual, L – language. Results in the table shows that the percentage success of students in

solving the corresponding tasks in the post-test in the majority of groups in the first class was higher than in the pre-test. The groups 2.NB, 1.C a 2.E were worse in the solving the task 1* compared to the task 1. The situation in the second class was slightly worse. Three groups of students (Sexta B, 3.NB, 2.D) received worse results in the post-test by solving both tasks.

A more detailed analysis of student solutions of both tasks in the pre-test and the post-test was the starting point for finding the reasons of the above findings. Analysis of the pre-test results shows that students often chose by solving task 1 the incorrect answer c) (15,4%) and the combination of the answer c) with another answer appeared in 32,6% of students. The reason of this error could be most likely inconsistent interpretation of the data from the graph. Students most often chose from the incorrect answers the option d) (17,5%) and the combination of the answer d) with another answer appeared in 33,1% of students. This finding could point at the use of incorrect connection between the average speed of runners and mutual position of graphs. In that the graph representing the movement of the runner A was above the graph representing the movement of the runner B three-quarters of the observed period of time, some students incorrectly concluded that the runner A had higher average speed than the runner B in the first 16 minutes.

We oriented the correct answer just on average speed in the formulation of the corresponding task 1* in the post-test. 38,9% of students chose the correct answer d) and the combination of this answer with another incorrect answer appeared in 49,4% of students. Given the fact that students of six groups reached the worse results in solving this task in the post-test than the pre-test, can be assumed that the formulation of the task in the post-test influenced obtained results in some detail. 13,9% of students chose in the post-test incorrect answer c), which corresponds to the incorrect answer c) in the pre-test. The combination of this answer with another incorrect answer appeared in 24,7% of students. From these results it can be concluded that students were not improved significantly in the analysis of graphic information.

When solving task 2 in the pre-test many students chose only one correct answer. 39,8% of students chose only the correct answer b), 20,5% of students chose only the correct answer e). 4,8% of the students chose both correct answers. We can assume that some students did not analyse other answers after finding a correct one. However, bigger group of students chose the correct answer b) can also relate to the fact that this answer represents the processual approach to solving the problem. Answer e) on the other hand represents more complicated method in which it is necessary to subtract the total discount for 24 nights from the total full price fees.

The described assumptions were proven to be true in regard to the results of solving the task 2* in the post-test. The answer representing the processual approach to solving the problem was listed as d), therefore after another correct answer that represents the full price expenses which is listed as a). 46,9% of students chose only the correct answer d), 23,3% of students chose only the correct answer a). The students could find the equivalence of these answers also using simplification the right sides of the equations. We assume that the students did not use this possibility as it is shown by the fact that only 6.9% of students chose both of the correct answers. These results show that students' inquiry skill to express the relations between variables using symbolic notation improved significantly compared with the skill to interpret information from graphs. Statistical testing also confirmed this finding.

Summary of success by class, specialization and gender found using statistical tests is presented in the table 2.

Class, gender, specialization	Pre-test		Post-test		Results	
	1	2	1*	2*	1 - 1*	2 - 2*
1	37,98%	33,23%	36,57%	40,67%	Same	Higher
2	32,76%	36,78%	40,91%	42,86%	Same	Higher
Male	44,16%	38,96%	46,62%	44,74%	Same	Higher
Female	25,84%	31,46%	32,26%	39,35%	Same	Higher
G	32,02%	33,71%	44,94%	42,09%	Higher	Higher
B/L	29,32%	32,76%	20,83%	37,50%	Same	Same
M	46,88%	43,75%	46,55%	49,14%	Same	Same
Total	**35,25%**	**35,09%**	**38,89%**	**41,84%**	**Same**	**Higher**

Tab. 2: The evaluation of results

We used to verify defined hypotheses H1 and H2 the one-sample and two-sample Wilcoxon test with a significance level of 0,05. The hypothesis H1 was confirmed on the significance level for both monitored skills. Although from the perspective of the average achievements the skill to interpret information from graphs were improved in several groups but this result was not confirmed statistically.

More significant improvement occurred in several groups in the skill to determine and express the relationships between variables what was confirmed at the significance level of 0,05. The most significant improvement was in groups with general specialization. Significant improvements occurred in both genders but the level of acquisition of these inquiry skills is higher among boys than girls. This fact was confirmed using the two-sample Wilcoxon test. Improving in the skill to express relationships between variables in symbolic form was statistically confirmed in both classes. We have expected that differences in achievement levels of measured inquiry skills among the first and second classes will be markedly better in favour of the second class.

Achieved results in the post-test are overall lower than we expected. We see reasons in several facts caused by the real conditions in the school practice. Teachers participated in the project taught only two subjects of mathematics, physics and informatics at some schools. Some teachers did not fulfil the specified range of implementation of inquiry activities due to lack of time. Because of the diversity of curricula, teaching of some topics was time-shifted and it extended the duration of the experiment up to double time for the planned scope of the inquiry teaching. It could have an impact on the effectiveness of innovative teaching.

Conclusion

The acquisition of inquiry skills to analyse and interpret the relationships between variables is the basis for the development of the competencies to model real situations and solve real life problems. When creating methodical and teaching materials, a great emphasis has been placed on the use of graphical representation that is essential for understanding the functional dependencies between quantities. Static but mostly dynamic visualizations created using the

dynamic geometric system Geogebra are very important for understanding mathematical relationships and generalization of the discovered findings. Results of our research has proven that systematic and coordinated use of inquiry approaches to the teaching of mathematics, physics and informatics has significant effect on the development of the students' inquiry skill to analyse, understand and express the relationships between variables with the significance level set at 0,05.

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ADVANTAGES AND BARRIERS TO THE INTRODUCTION OF E-LEARNING ENVIRONMENT INTO ACADEMIC TEACHERS' ACTIVITIES IN UKRAINIAN UNIVERSITIES

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Abstract

With the development of information society it is becoming particularly needed to construct high-quality system of higher education, aimed at shaping the skills of life-long learning. This is determined by the existing contradictions between continuously increasing volume of information required for people to maintain their competitiveness on the labour market and limited opportunities of traditional educational system to gain knowledge, abilities, skills and other competencies. To resolve this contradiction, educational programs should, above all, be consistent with the principles of multilevel, complementarity, handleability, continuity, integration and flexibility. In our view, significant prospects in relation to these principles and improvement of modern higher educational system are presented by the introduction and development of university e-learning environment. The paper presents barriers to the introduction of e-learning environment in Ukrainian universities, as well as discusses professors' opinions, received via a sociological survey.

Keywords

ICT-tools, ICT-competence, e-learning environment, questionnaire

Statement of the problem

The creation of e-learning environment is currently the main task that determines the success of the introduction of information and communication technologies in education at all levels. The management and professors in higher educational institutions take the leading role in this process, who, on one hand, need to encourage teachers to use the new ICTs in the educational process, and, on the other hand, the teachers themselves must understand that from the knowledge that the future of the whole society and the state depends on the knowledge they

impart to students and their compliance with the latest theoretical developments and aspect of professional life. Mastering ICT technologies improves the efficiency and quality of educational process: enables students to grasp material, using their perception of graphical, audio or animated form at a higher level; automate and make more the quality control system more transparent in order to access and manage large volumes of information, etc. It is teachers who should become facilitators of information flow, they should guide and promote students' creative activity, which will permit differentiate and individualize training, increase the interest to the disciplines taught.

Introduction

In contemporary scientific discourse there is a considerable number of publications researching into aspects of use of electronic tools in the learning process, the forms of interaction between teachers and students in e-learning environment, the strategies of HEIs in Ukraine and Europe as to the application of information technologies. Much attention is paid to reviewing the existing legislation on implementing e-learning, crucial educational provisions for distance learning and various aspects of its organization, methodological principles of e-learning and didactic aspects behind the creation of electronic textbooks and more. Much attention is paid to finding and analyzing various ways to build a system of training future teachers in the field of ICT.

Related work

Among the latest research in this area it is necessary to mention the developments of such scholars as R. Gurevich, N. Morze, A. Glazunova, T. Petrenko, G. Kozlakova, T. Kovalyuk, Yu. Tarasich, E. Spivakovskaya, M. Kademiya, V. Gorodyska, Yu. Burovytska, T. Derkach, V. Rakhmanov, O. Naumenko, O. Torubara, A. Zabolotskii and others.

The willingness of teachers to use distance learning technologies was investigated in the papers of N. Morze. They demonstrate that the improvement of quality of training depends largely on the professional expertise of teachers and their mastering of modern methods of innovative teaching, including distance learning technologies because traditional education can not meet the growing demand for training, advisory, reference materials in any place and at any time. Progress in IC competences improves professional competence of the teacher and is one of the primary needs of modern training and self-improvement of teaching staff. The article determined competency in distance learning technologies, discusses indicators for their evaluation, approves a method to evaluate competencies via a method of 360 degrees using specialized software (Morze, Glazunova, 2012). The researcher singled out ways to use webinar-oriented platforms as a tool for teachers; summarized the advantages and prospects of webinars during the implementation of remote form of advanced training of university teaching staff, analyzed the efficiency and prospects of webinars for in-service training for teachers (Morze, Kocharian, Varhcenko-Trotsenko, 2014).

Petrenko T. (Petrenko, 2011) in his article notes that in today's information society, during the implementation of Bologna principles into the educational system traditional teaching methods are enriched by the use of ICT and profoundly change the stable system "teacher - student" into systems "teacher - a computer - student" or "student - computer - information technology" or "student - a computer." The teacher ceases to be the sole source of information. Teachers acts as intermediaries, so they have to interact with students after fundamental training in modern ICTs. Thus, contemporary challenges force teachers to use modern ICTs in teaching which will improve the efficiency of the educational process as a whole. The main disadvantage behind

the use of computer technologies is the reduction in direct teacher-to-student and teacher-to-audience communication, considerable expenses to equip schools and universities.

Regarding teacher ICT competences Kozlakova G. and T. Kovalyuk (Kozlakova, Kovalyuk, 2009) prove that on the whole they meet current level of ICTs, but this correspondence is true only when teachers have part-time duties to develop software, information systems and technologies and introduce them appropriately to the industry. In reality, professors are generally absorbed with their teaching which lacks connection with contemporary activities in enterprises. And universities, unfortunately, can not keep up with contemporary ICT developments. Therefore, the level of teachers' ICT skills should be supported via real training in modern companies.

Tarasich Yu. and Spivakovskaya E. (Tarasich, Spivakovskaya, 2013] discuss the benefits of ICTs for teachers and stress that the new ICTs present unique prospects to intensify educational process – due feedback, visualization of educational information, accessibility of scientific literature and teaching aids, management of knowledge quality control etc. E-learning instruments allow students to focus on the issues currently discussed, to determine their level of information competence, to familiarize them with modern teaching aids, to coordinate the work of the group. The use of ICTs in active learning triggers different modes of perception and dissemination of information, improves the clarity and appeal of the training material, and hence the quality of educational services and knowledge.

Describing the requirements, advantages and disadvantages of the introduction of e-learning in the educational process of the university, M. Kademiya (Kademiya, 2014) convincingly proves that the use of electronic technologies in learning is beneficial for the psychological and pedagogical aspects of teaching, in particular it promotes the development of students' and teachers' individual resources, forms the skills of goal-setting, independent thinking, initiative and responsibility for their work, and also reduces the psychological burden on students and teachers in the process of mutual exchange of knowledge. Advanced training for academic staff in the field of Internet technologies, the use of various forms of e-learning contributes to the development of international cooperation in the educational environment.

In contrast, Gorodyska W. (Gorodysky, 2015) considers it inappropriate today to urge academic staff for the immediate, widescale and hasty application of ICTs in universities; namely interactive side of them - using Internet-based services, including concept maps, blogs, wiki, email, chats etc.). Despite their progressiveness and efficiency in professional teacher's work, the researcher stresses the need for the teachers' to follow the habitual sequence of actions, and to combine traditional approaches and innovative technologies. However, it is considered vital to ensure the applicability of ICTs to the available facilities of universities, to personal teachers' needs, their professional competency and openness for innovative changes.

Among the barriers holding back the introduction of ICTs in the educational process T. Derkach T. (Derkach, 2014) and Rakhmanov V. (Rakhmanov, 2014) mention the lack of didactic methodology and scientifically proven recommendations for their practical application in higher educational institution. The development of ICTs is far ahead of psycho-pedagogical interpretation of the consequences behind their implementation, while reorganization of traditional forms of teaching based on ICTs is challenged by the lack of training in teachers and relevant skills. The prospects to increase the efficiency of the educational process are not fully implemented in practice.

This view is largely supported by Burovytska Y. (Burovytska, 2016), who states that currently many teachers do not know how or are unable to use modern technologies. While currently, the ability to use knowledge and skills in information technology are one of the most important

indicators of expertise of academic staff. Being able to run a personal computer is an indicator of a generally educated person. One needs to train future teachers to use information technology in the context of their future work. There are two significant factors that hinder the process of implementing ICTs in educational system: general information competence of the teacher and the ability to implement multimedia technologies in their activities, not to be only a user for readymade software products, but more as a creator, developer of their own teaching software (Naumenko,2007).

Exploring professors' opinions to the introduction of ICTs in professional activities Zabolotskii A. (Zabolotskii) stresses that the necessary conditions are: personal assurance as to the usefulness of ICTs at different stages of the learning process; the availability of computer equipment; professionally designed software for learning teaching materials; knowledge and skills to use ICTs. The main factor that hinders the implementation of ICT in teacher professional activity is motivation. Motivation to improve their work via ICTs is certainly to be addressed by the administration of the institution.

However, despite relatively high interest in the use of ICTs in higher education modern scientific discourse of today still lacks scientific publications analysing the results of empirical sociological studies revealing teachers' attitudes and motivations as to the use of new technologies in professional activity, their opinion of benefits and challenges of ICTs in educational process.

The purpose of the article is to determine the benefits, motives and barriers to the implementation of electronic educational space in the professional activity of teachers of higher educational institutions of Ukraine.

For more detailed analysis of this issue a case study was carried out to determine the scope of use of information technologies in science, means the integration of scientific and teaching activities, assessment of teachers' actions in electronic environment, the advantages, issues and motives, preventing the introduction of e-learning technologies in teaching. This study was carried out in the framework of the international project «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». Project is financed by the European Commission under the 7th Framework Programme, within the Marie Curie Actions International Research Staff Exchange Scheme. Project participants are universities in, Poland, the Czech Republic, the Slovak Republic, Portugal, Spain, the Netherlands, Ukraine, the Russian Federation and Australia. One of representatives from Ukraine in this project is the Dniprovsk State Technical University.

Selecting Dniprovsk State Technical University as an object of study is due to the fact that it is an average university in Ukraine, which allows to apply the research results to a wide range of technical universities in Ukraine.

A sociological study was conducted using a special toolkit in May 2015 by electronic questionnaires which involved teachers and heads of structural divisions of DSTU. The survey involved 53 employees of the University, of which 89% are scientific and teaching staff (59% - associate professors, 26% - teachers, 4% - professors) and 11% - heads of departments. Empirical data permits to make some conclusions about teachers' use of ICT in scientific and professional development.

Hypotheses of the study:

1. The main advantage of electronic educational environment for teachers is open and unrestricted access to relevant professional information.

2. The main challenge to the implementation of e-learning technologies in teaching activities is the lack of scheme of incentives for the introduction of information technologies in universities.

3. The main motifs of the introduction of ICT in educational activities is the professional self-realization, improving the quality of students' education and the desire to expand their educational opportunities.

4. Teachers' demand as to the use of e-learning exceeds the level of development of the e-learning environment of the university at the moment.

Statement of research results

The results demonstrate that the greatest benefit for teachers in e-learning environment is access to professional information - it was chosen by 17.7% of teachers (Figure 1.). Also, a significant number of respondents among the main advantages of this environment mention information processing and communication in digital form using general computer-based tools (office applications, e-mail and other). This advantage was preferred by 16.2% of DSTU employees. Among other significant advantages of electronic educational and scientific environment academic staff chose the possibility of using specialized electronic tools in professional environment (13.7%) and ease of access to information related to the management (12.4%). Among the least evident benefits for the respondents we observed the organization of network communities, their management (2%), participation in these communities (3.6%) and access to their resources (5.6%).

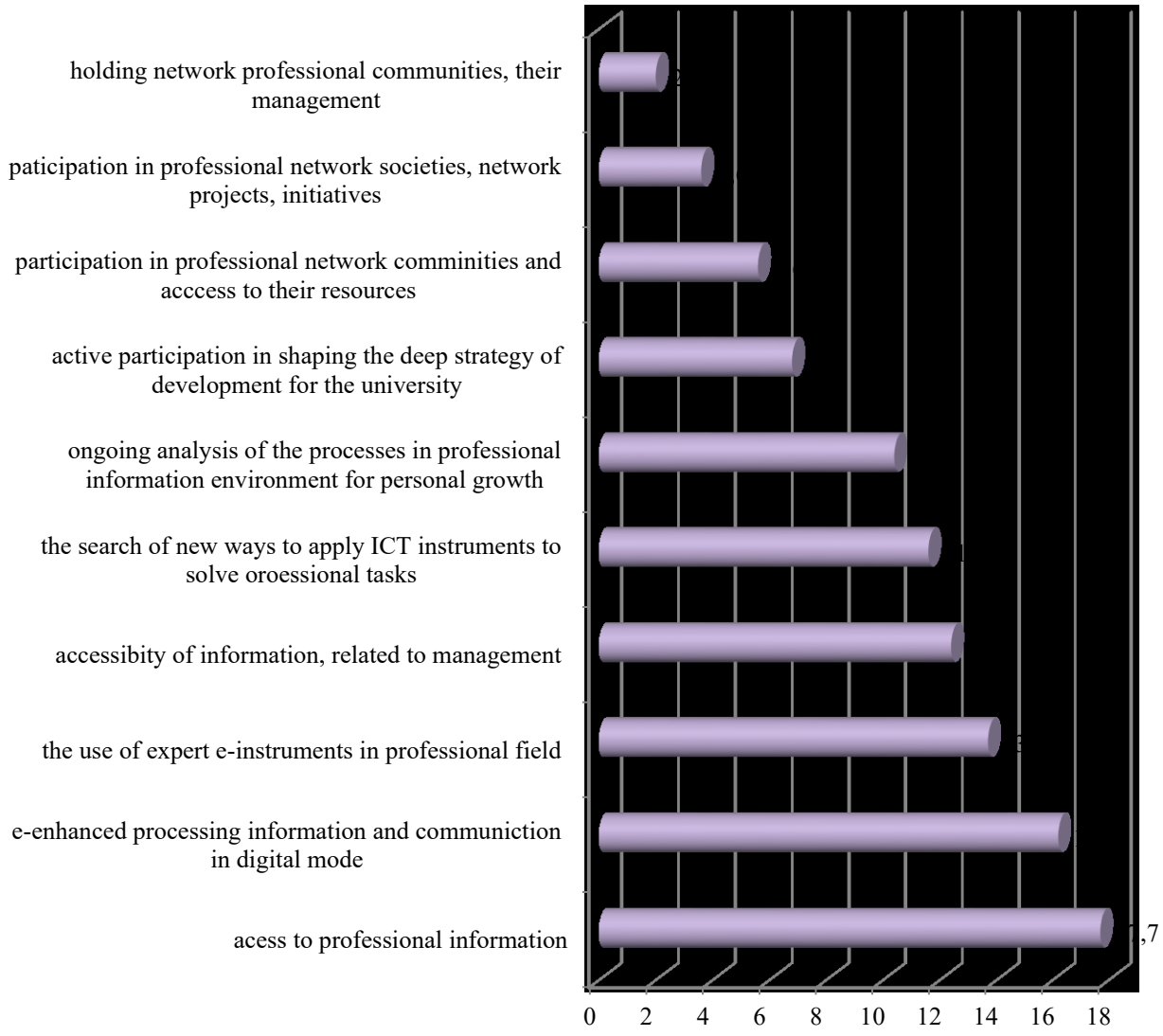

Fig. 1: The advantages presented by e-learning environment and scientific e-environment (in %)

It is undeniable that the main advantage of e-learning is access to training at any time and in any place. The use of distance learning technologies can have such advantages for students as efficiency, accessibility, training at their own pace, freedom and flexibility, mobility and workability. It is also necessary to highlight the benefits not only for learners but also for educational institutions, namely, reduction of costs on education; a possibility to train a large number of people; improving quality of education through the use of modern means of capacious e-libraries, etc .; creation of a unified educational environment. But, at the same time it represents an additional burden for teachers, since with individualization of learning teachers' time depends on when students want to get in touch with them. This means that the teacher should always be "in touch", that is, should have access to the Internet without weekends or holidays. All this raises a problem of adequate regulation of teachers' labor and decent pay, corresponding to their significant efforts at workplace.

On the other hand, e-learning can not be implemented without quality content, i.e. materials needed in training - e-learning courses, tutorials, presentations, tests, etc. In this case, the main problem lies in the fact that at the moment most of Ukrainian universities (unlike in Europe), have no institutional requirements for the structure of such courses and incentives (financial

and moral) for teachers to development and implement them in educational environment. An equally painful barrier to the introduction of e-learning in teaching activities is the quality of technical equipment, especially in regions where the communication channels are often of poor quality which significantly complicates the process of learning. The problem of quality of e-learning is also very important (how and who can evaluate e-courses); legal issues related to the protection of intellectual property; financial issues related to expenses on the development of e-courses and their update; the management of advanced training for staff who are able and willing to develop and continuously update such courses. The above mentioned problems are typical for the whole Ukraine.

As to specific problems of each individual university, the results of our research demonstrate that a major challenge for the implementation of e-learning technologies in teaching activities in DSTU is underdeveloped system of incentives for the introduction of information technology in higher education – with every fourth teacher thinking this way (Figure 2.).

Let us present some sociological background as to people's motivation in actions. The sophisticated hierarchical system of each individual's needs, accompanying people in their daily reality, determines motives of their actions. According to the classification of J. Galbraith, human behavior in economy is determined by the motivation system formed for each individual by combination of four basic motives: fear, desire for money (material) compensation, adjustment and identification of objectives. The mentality of Ukrainian people is built primarily on stimulating from the outside - it is important that these objectives are not created by ourselves, but by the people who supervise us. That is why at the moment there is a pressing need for educational authorities to develop education standards and requirements for teachers' professional qualifications.

The results of sociological monitoring show that today the leading motifs for work are financial incentives (stability and monetary compensation). However, university teachers do not see receiving material benefits as having utmost value, for the sake of which they are engaged in professional activity. Researchers Skrauch O.N. (Skrauch) distinguish among the leading motives of teachers' academic activity the following:

- self-fulfillment, the prestige of the course, image and prestige of the university, career opportunities;

- cognitive process, the search for truth, interest in the chosen course, the desire to conduct research, creative nature of work;

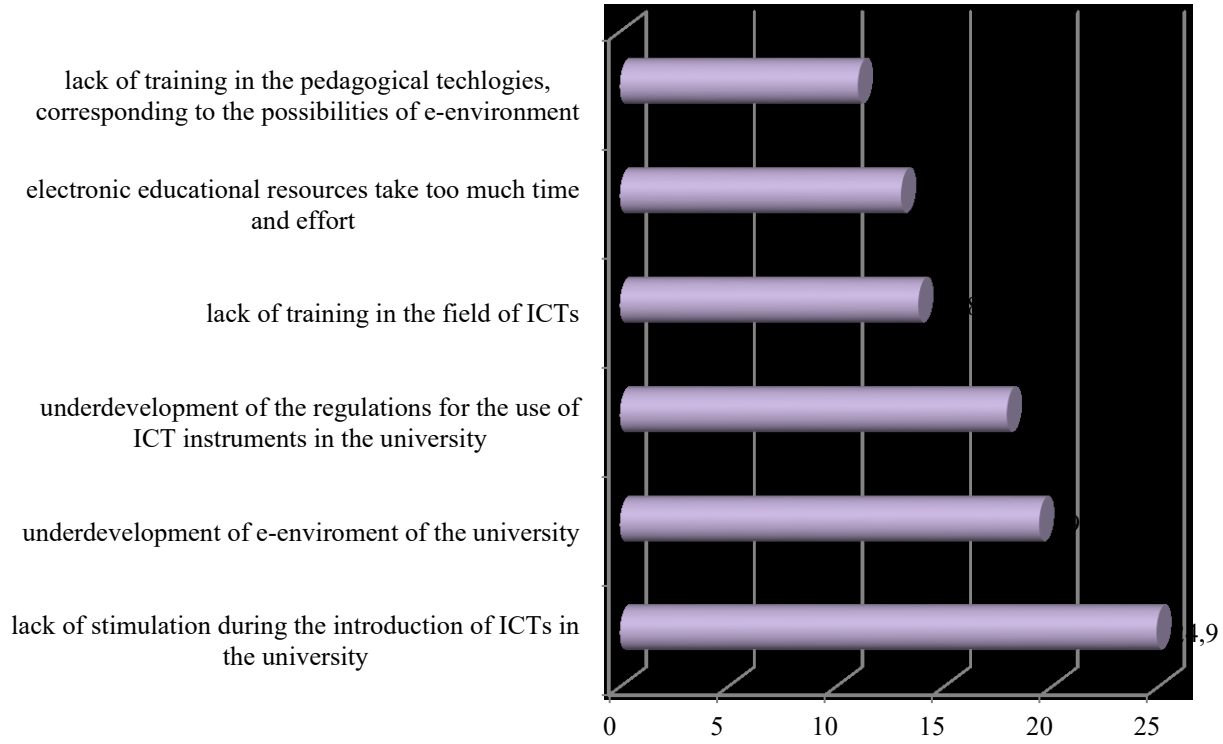

Fig. 2: Barriers to the introduction of technologies in teaching (in %)

- social motives - the intention to transfer knowledge and experience to the younger generation, interest in educational work, the desire to benefit society;

- financial incentives – increase in income, the opportunity to gain additional income;

- self-affirmation and self-development – advanced training opportunities, recognition of academic degrees and titles, the prospects to improve intellectual potential, belonging to the family dynasty;

- other motifs - convenient working hours, long vacation in summer, employment in a state institution, favorable intellectual and cultural environment, etc..

That is why the main problem for the introduction of distance learning is lack of regulation on the use of information technologies and appropriate material incentives for teachers. This stimulation can be a differentiated pay in connection with individual scope of use of ICTs by teachers and pay increase, etc.

The problem mentioned above is also tightly linked to problems of underdevelopment of e-learning environment of the university (19.4%) and missing regulations as to the use of electronic instruments (17.9%). Besides, a fairly common problem is also certain lack of training in ICTs (13.8%), labor intensity and complexity of efforts in the development of electronic educational resources (13%), lack of training in the field of educational technologies (11%).

Along with this, we need to mention lack of teachers' motivation to use ICT in teaching. Most teachers will to use the latest technology and they see prospects in the technologies, but many of them need encouragement to invest a lot of their precious time, which they might need to spend for further changes. They understand that the opportunities offered by technology make the task more difficult and those changes will take a lot of time. However, computer literacy is the kind of investment that will largely cover all expenses in the long term. If computer

technology have such significant impact on learning and teaching of a particular subject, the teachers should feel comfortable with the latest technology, seeing them rather as means of further development, not something that interferes with their everyday professional life (Burovytska, 2016).

The research data of our survey showed that the majority of teachers (17.2%) chose improving the quality of students' education and the desire to extend educational opportunities for students - 16.9% (Figure 3.) as the main motives of introduction of information and communication technologies in educational activities.

At the same time it revealed that such motives as the desire to conform to the requirements for academic university professors (14.2%), the desire to make their profession more comfortable (13.4%) are less important for teachers. That means that professors the teacher do not so much look for their convenience and the achievement of their personal and professional goals, but they do try primarily to facilitate students' efforts and desire to give them better education.

We agree with the opinion of Dyachenko S.A. in claiming that the development of information culture of university teachers comes with advanced training. A professor willing to create his own e-learning course may need the help of experts from various fields of knowledge. In this connection, it is logical to start creative laboratories or clearing houses, consisting of administrators, coordinators, technicians, consultants, assistants and other teachers who specialize in certain issues. To improve professors' information awareness during their development of e-learning course it is possible to conduct workshops on corresponding software products (Vylegzhanina, Maltsev, 2015). It is necessary to establish a system of ongoing methodological support for teachers on the use of ICTs in teaching, scientific research and professional development.

Teachers' desire to use ICTs in their professional activities, especially to improve quality of students' learning, in our opinion is due to the fact that multimedia technologies increase the quantitative and qualitative indicators of memorized material in comparison to simple listening to a lecture. Teaching with ICT technologies includes the use of material in visual and audial forms which is better memorized by students.

This confirms the research of American scientist and educator E. Dale, who in 1969 came to a conclusion that mere reading some relevant literature or listening to lectures is one of the most inefficient ways to learn something. At the same time, the use of teaching material and teaching it to others was recognized by professor as one of the most effective methods of learning any material. The teachers, being able to access the resource used, may create their own e-courses, enrich them with the necessary methodological support, use the necessary electronic means for educational purposes to improve the intelligibility of the material offered. Students, having access to the resources offered by the teacher gain more access to self-study materials, online discussions, visual perception of information.

According to the study on influence of ICT use on the quality of educational services of universities, based on a comparison of studies determining the quality of distance learning systems (LMS) and IT infrastructure of higher education institutions as of 2009-2010 and 2012-2013. It found that in 65% of institutions the quality of their IT resources directly influences the quality of students knowledge, with 25% saying that "to date, the impact of the quality of distance education systems on the quality of students' knowledge is negligible," and 10% indicate the absence of any influence. The indicators of quality of methodical support for e-learning resources are considered the most influential group of factors that affects quality of

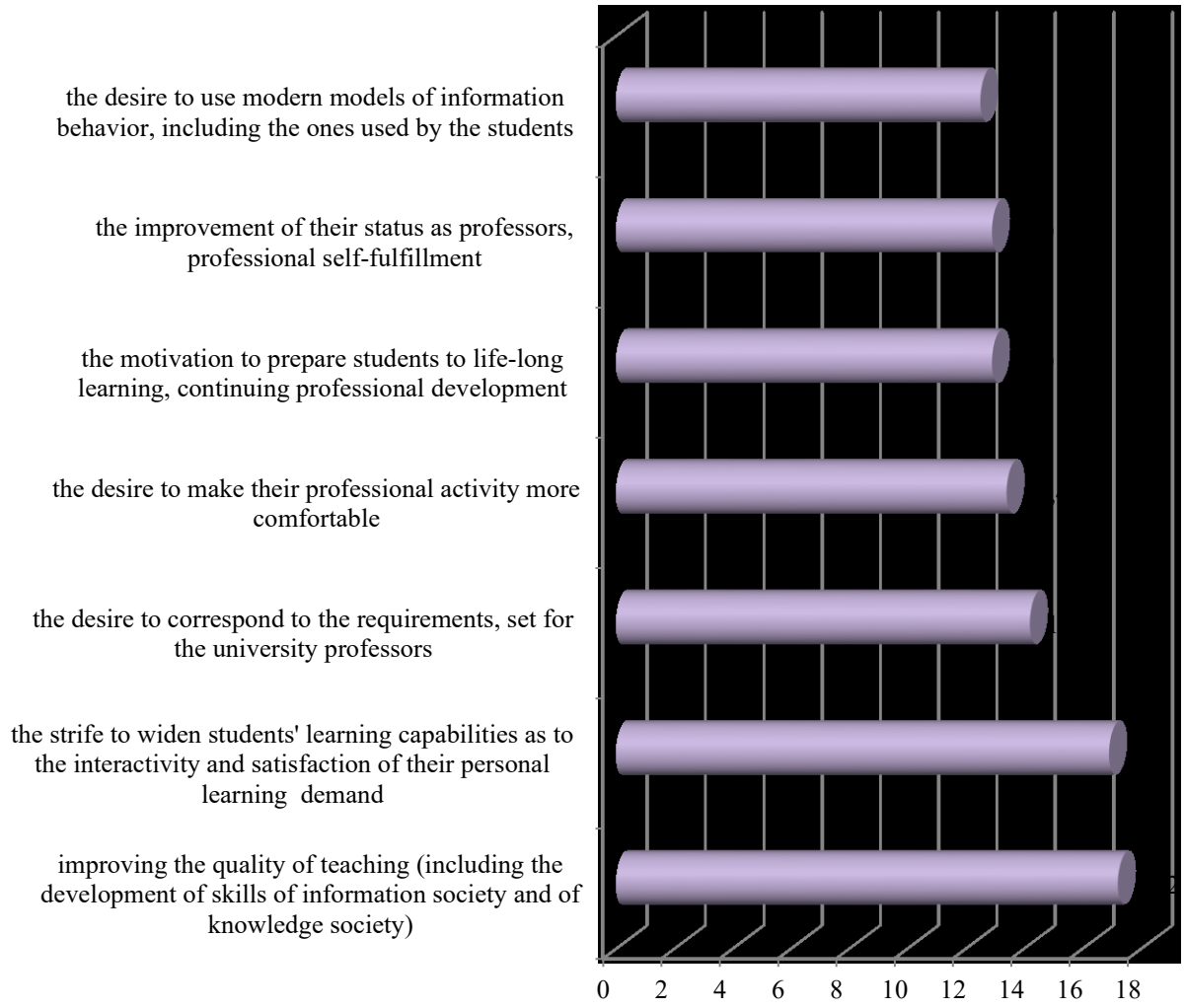

Fig. 3: The value of motives behind the introduction of ICTs in professors' activity (in %)

education today, this influence today having increased by about 15% over the past few years. Partial increase of this index is determined by improvement of IT-equipment in universities, increasing the number of staff trained to implement and use modern ICTs and e-learning resources in the educational process (Tarasich, Spivakovskaya, 2013).

The data in our survey also confirm this idea, they allow us to state a fairly high degree of readiness of our university teachers to use ICT in their professional activities. But in this context there rises another problem - the quality of University e-learning environment (Figure 4.).

In our survey we asked professors to evaluate from 1 to 5 points the way electronic environment of our university (computers, networks, wi-fi, LMS, e-library, e-repository) responds to their needs and we found that a third of university professors (33%) give the University environment the highest score. 27% of respondents evaluated this point with four points, together they make 60%. This means that positively-minded respondents are significantly larger in number compared to 20% of those who assessed e-environments' compliance with their demands with minimum points (one and two). That signifies that e-learning environment in DSTU created the information conditions for full implementation of e-learning

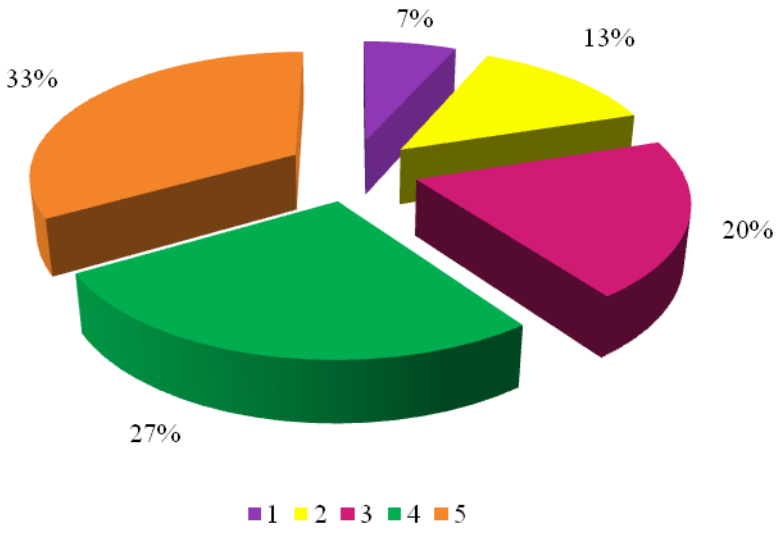

Fig. 4: Correspondence of professors' demands in the use of e-learning instruments within university e-environment (in %)

At the same time, a fifth of the teachers who participated in the study chose an average rating of 3 points that can be explained by the fact that some middle-aged and elder teachers respondents currently have low level of computer literacy, lack general computer and Internet skills, and thus, they do not use electronic resources of the university in their teaching.

Conclusion

Thus, our survey demonstrated that the skills of using ICT-tools in professors' professional activities is a necessary condition for the improvement of modern higher educational system, aimed at improving the quality and effectiveness of training. The development of e-learning environment promotes self-realization and self-assertion of university educators, contributes to a smoother educational process and cooperation with students. The scope of implementation of electronic educational space in teaching depends largely on professors' information culture, cognitive style, skills and methods of ICT use in different types and forms of educational activities, as well as in respective subject, the already developed skills to develop ICT-based educational technologies. At the same time, a significant barrier to the introduction of information technologies in the educational process is the difficulties associated with transition from familiar, well-established technology to new, not yet sufficiently well-known and proven. Teachers are aware of the benefits provided by electronic educational and scientific environment and are willing to improve their skills with ICTs which make it possible not only to use new ICT-tools for teaching, but also develop their own. This is evidenced by teachers' willingness to expand their knowledge and skills in the use of information and communication technologies in teaching.

Upon checking the main hypotheses we have been able to state the following:

1. The main advantage of the electronic educational environment for the majority of teachers are open and unrestricted access to the necessary professional information - 17.7% of the surveyed teachers have given preference to this advantage. The hypothesis was confirmed.

2. The main challenge to the implementation of e-learning technologies in teaching activities is the lack of incentive scheme for the introduction of information technologies in universities. The hypothesis was confirmed, as every fourth teacher pointed out this problem.

3. The main motifs of the introduction of ICTs in educational activities is the professional self-realization, improving the quality of students' education and the desire to expand their educational opportunities. This hypothesis was not fully confirmed, as it was found that the main motif of teachers was to improve the quality of students' education - 17.2%; secondly, the desire to expand the educational opportunities for students - 16.9%; thirdly, the desire to meet the requirements - 14.2%. Professional self-realization as a motive for the introduction of ICTs was chosen by only 12.9% of respondents and took the fifth place in teachers' ranking.

4. The hypothesis that teachers' demands as to e-learning tools exceed the level of university e-learning environment has not been confirmed. It was found that 60% of teachers rated as "5" and "4" the compliance of their demands to the capabilities of university e-learning environment.

The authors see prospects for further research in identifying specific objectives and instruments used by teachers to improve their information and communication competences and optimize educational process in the information society.

Acknowledgments

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CROSS-CURRICULAR APPROACHES IN INQUIRY-BASED SCIENCE TEACHING

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Abstract

One of the most important goals of science education is to develop understanding of natural systems. It is impossible to comprehensively understand the functioning of natural systems only by knowledge of one subject (physics, chemistry, biology, etc.). Therefore the application of the cross-curricular approach in teaching of science subjects is required. Besides the scientific knowledge the understanding of science research methods is important, too. This can be obtained with the use of inquiry-based activities in science lessons that provide possibilities to show students how science works. The aim of this paper is to introduce the strategy for the use of cross-curricular approaches in inquiry-based activities in science education that was implemented within the Chain Reaction project. The project targeted 14- to 16-year-old students who in groups investigated an interdisciplinary research problem and then presented their findings and experiences at national or international events. Cosmic Web Site represents an example of the activity that encourages students to learn various topics of physics as well as to use their knowledge and skills obtained at computer science lessons. The feedback from the teachers involved in Chain Reaction that was gained with the help of evaluation questionnaires indicates a positive impact of the used approach to the development of students' skills and motivation to learn science subjects.

Keywords

Inquiry, cross-curricular relationships, physics, informatics, Big Bang theory

Introduction

Inquiry, increasing an activity of students during science lessons, development of scientific literacy are the most discussed topics within the professional community. Besides these ones the cross-curricular relationship between science subjects is also an interesting topic mainly if we talk about inquiry, inquiry-based activities or about similar methods supporting development of scientific competences.

By Savage (2010, pp. 8 – 9), a cross-curricular approach to teaching is characterised by sensitivity towards, and a synthesis of, knowledge, skills and understandings from various subject areas. It means that the subjects contain more than knowledge and skills, they contain mainly "understandings".

We can say, just "understanding" is one of the most important goals of science education and the implementation of inquiry-based activities which uses cross-curricular links seems to be a suitable tool for development of this one.

An inquiry-based approach to science education engages students in activities which resemble methods of scientific investigation, with content interwoven with or addressed in the context of inquiry (Kubicek, 2005), (Hruška, Holec and Raganová, 2013). Inquiry is a process in which at first the problem must be recognised, then suitable experiments are suggested together with appropriate alternatives, design of the study procedure, creation of hypotheses, search of informations, creation of models, discussion and formulation of logical arguments (Linn, Davis & Eylon, 2004). Thus inquiry is not concentrated on a passive way of gaining knowledge but on the development of logical thinking, the ability to argue, formulating problems and searching possible solutions (Crawfordová, 2000).

These objectives can be realized through activities with different degree of independence of the student. On one side we can talk about activities that are fully managed by the teacher, on the other side there is an independent activity of the student which begins with the formulation of the problem to be investigated. A hierarchy of inquiry activities (tab. 1) was constructed according to the scale of student independence (Wenning, 2010), (Ješková, Kireš and Kedzierska, 2012).

Interactive demonstration / discussion	Limited Inquiry	Structured Inquiry	Guided Inquiry	Open Inquiry
Lower	← Intellectual Sophistication →			Higher
Teacher	← Activity managed by →			Student

Tab. 1: Levels of inquiry

Inquiry activities which require an independent work of students and increased support by teaching materials – the guided inquiry and the open inquiry – were chosen as a core approach at the international project Chain Reaction.

Chain Reaction project

Chain Reaction (Chain Reaction, 2016) was a three-year project funded by the European Commission under the 7th Framework Programme, which involved twelve partner countries. The aim of the project was the development and implementation of research activities in science education through solving the problems and inquiry-based learning, which aims to actively engage students in learning science and allow them to experience the excitement and challenges of experimental science and research. Teachers who participated in the project were trained within an introductory course, where they had the opportunity to gain theoretical knowledge of

inquiry-based methods used in the teaching process, as well as basic practical skills in implementing and managing such activities. After gaining practical experience with inquiry-based teaching methods, involved teachers taught a series of lessons which formed an introduction to subsequent research activities of students.

Teaching students to do scientific inquiry involves teachers engaging their students in the practices of science. These practices include various activities and processes carried out by scientists to answer questions and develop explanations and models using logic and critical thinking. As they engage in scientific practices, both students and scientists use observations and inferences to develop conclusions and evidence-based explanations.

Earth & Universe Pupil Research Briefs

The ambition of the Chain Reaction project has been to provide teachers strong and continuing support in inquiry-based science education not only in the form of courses and workshops, but also in the form of teaching materials. For this reason, a set of materials called *Earth & Universe Pupil Research Briefs (EUPRBs)* was created containing 11 research activities in various fields of natural sciences. Eight of them were adopted to suit Slovak context: (1) *Collision Course*, (2) *Green Light*, (3) *PHEPPS*, (4) *Feed the World*, (5) *Ozone Conference*, (6) *Cosmic Web Site*, (7) *Plants in Space*, (8) *Green Heating* (full texts of these materials are available at the project website www.chreact.umb.sk).

The structure of each activity (fig. 1) corresponds with a simple model that has been designed to allow teachers and students to understand, as far as it is reasonably possible, how researchers in the field of science and technology think and work.

Fig. 1: The EUPRB model (EUPRBs, 2013, p. 4)

The proposed model shows the steps of the research which are divided into a structured methodology. Scientific research, whether real or school, is not straightforward and it is impossible to accurately determine the sequence of steps that need to be implemented. A research project can have numerous false starts and blind alleys, and work can be carried out along several lines of enquiry at once. Activities which tend to come only at the end of a school science investigation (such as report writing or communicating findings) tend to occur at all stages in a research project. Discussions with science and engineering researchers showed that

all four categories of activity could be going on simultaneously within any one research project (EUPRBs, 2013, p. 4).

The four stages of the EUPRB model

A) Context setting

All research projects exist for a reason: the personal interests of the researcher, a particular issue/question raised by the research community, a link to a commercial enterprise etc.

In attempting to simulate this professional world of research, it is important to construct curriculum scenarios where the purpose of the investigation is made clear to the students. The EUPRBS have been constructed so that the students are led in by means of one or two activities which establish the context for what is to come. This is brought about by a number of types of documents – emails, press releases, newspaper or journal articles, letters, etc. These have been designed to simulate 'reality'.

B) Background knowledge

In the beginning, obtaining sufficient information on the subject (the literature review), and the results of other studies carried out in this area (exploring various information sources) is important for the successful solution of the research project.

The EUPRBs attempt to represent this range of activities by means of 'research papers' specially written for the purpose, reports, meeting summaries, extracts from books and notes. All, written at a language level the students can understand. The documents used in the context setting and background knowledge categories of the EUPRBs involve students in a wide range of active learning approaches such as small group discussion, problem solving, active reading and brainstorming. These activities will help them to think their way into the investigation which is the focus of the EUPRB.

The first two phases of the EUPRB help to create the appropriate 'mind set', where the purpose of the investigative work is clear to the students, and where they have some stake in its successful outcome.

C) Investigation

The EUPRBs involve students in carrying out one or more investigations. The students begin by framing the question, hypothesis or prediction, or taking an idea presented to them and planning a procedure for the investigation. After carrying out their investigation they analyse their findings, draw conclusions and evaluate the outcomes.

D) Communication

Students are involved in communicating science in a variety of ways, reflecting the diversity of media and methods used in the professional world. Some EUPRBs require students to write up a standard laboratory report. Others involve writing proposals for funding or articles for journals, construct websites etc. (EUPRBs, 2013, p. 4).

The application of cross-curricular links in inquiry activities

The character of the majority of the developed activities requires the application of cross-curricular relationships. Science cannot operate as separate units as in solving various science projects it is important to use knowledge from different fields. For example, in the activity *Feed the World*, in the first step, when students need to produce a fertilizer, they have to intensively use their knowledge of chemistry. Subsequently, in the cultivation of crops (beans, watercress, etc.) they have to use their knowledge of biology. The situation is similar in solving the activity

Plants in Space, when students use their knowledge of biology, chemistry and partly also of physics.

In all of the proposed activities, the use of computer is commonplace, at least for preparation of presentations or other materials, which form results of the activity.

Cosmic Web Site

The situation is different in the case of activity Cosmic Web Site that has a different character and method of realization than other activities. The aim of this activity is to create a website to explain the theory of the Universe origin known as the Big Bang theory and other concepts and phenomena related thereto. At the beginning students are provided with the basic text and are asked to provide illustrations to go with the text and to identify words and phrases that need further explanation. New concepts together with their explanation will be included in the glossary. Text can contain more words and phrases that will require explanation. Students are to identify these and allocate the tasks of providing hypertext pages between them. They are required to look for the information to be put onto these pages and to find suitable images to accompany the text. The exercise should provide a comprehensive explanation of the Big Bang theory and how research currently being conducted is helping to shed light on the likely fate of the Universe.

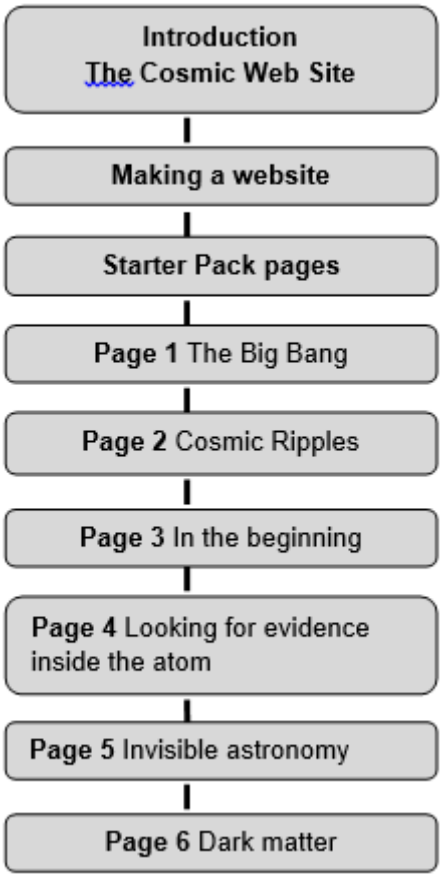

Fig. 2: Route through the activity (Cosmic…, 2013, p. 2)

The teacher's guide contains also a proposed route through this activity (fig. 2), which of course, may not be strictly adhered to. Students can work in different ways.

As the character of the activity shows, students must use the knowledge of physics and also of informatics at their work. In this case, the computer does not serve just as a mean of creating the presentation, in which the results of the work are discussed. The computer is an essential part of the activity and without its use it would not be possible to fulfil the stated objective.

Before attempting this activity, students should have a basic knowledge of stars and galaxies and an understanding of the structure of the atom would be a great advantage, as well. Besides, students should also have basic skills in using the Internet and in creating of websites. However, the creation of websites is not as unknown as it was in the past. The creation of websites has been incorporated into the state educational programme for secondary grammar schools within Informatics subject. Therefore, the technical realization of this activity should not be a problem for students. There is not strictly given, what tool should be used to create the website at the performing the activity. It depends just on the experience of students, which tool they choose.

Cosmic Web Site in the school practice

Research objective

The created activity was designed for physics lessons at secondary schools. After finalization of the teacher's and student's guide of this activity, our aim was to test how the activity described above could be implemented into physics lessons.

Target group

The activity was tested within the project during three school years – from 2013/2014 to 2015/2016. Each year, five secondary schools were involved in the project. As it was mentioned, at the beginning of the school year teachers of participated schools were trained within an introductory course with the aim to gain theoretical knowledge and practical skills in using of inquiry-based activities. After this course the teachers chose activities which they wanted to implement into their lessons.

The activity *Cosmic web site* was chosen by five schools. The best teams had an opportunity to present their work at the national conference organized each year within the Chain Reaction project.

Experiences and results

Feedback from implementing the activity into physics lessons was obtained by interviews with teachers. The results indicate several difficulties concerning time, needed preliminary knowledge and required computer skills.

The time consumption of this activity stated in the teacher's guide was estimated at three lessons. Realization of the activity, however, due to its comprehensiveness and technical difficulty, has required a significant amount of the free time of students. Three lessons were devoted to the performance of physical part of the activity as well as its technical implementation. Finally, it was necessary also to devote close attention to motivating students to carry out this activity.

The school practice has shown that in the beginning of the activity, students have to find, sort and study the amount of information related to the Big Bang theory. As it is a considerably abstract topic which is difficult to understand for students, lectures from experts were needed in many cases. Experts introduced the topic to students in a way appropriate to their level of knowledge. As mentioned earlier, the character of the activity requires a strong cross-curricular

work. Therefore students had to devote some time for choosing the appropriate tool for creating web sites and design of its structure during lessons of Informatics.

The results obtained during the three school years showed that most pupils were more focused on the technical side of the activity, such as a web graphic design, a source code, interactivity and functionality of the web site. Thus the physical nature of activities was downgraded. This may be caused by the complexity of the physical basis of the activity. Based on these results we must conclude that a given activity is preferable to use in the informatics lessons, where students learn to work with graphics and to create websites.

a) 

b) 

Fig. 3: Samples of portals Cosmic web site created within the project
a) vesmirny-web.webnode.cz b) www.egymbb.sk/vesmir/

Despite the complexity of the topic, students' motivation was so great, that they devoted almost all their free time to realization of this activity. It is gratifying, that in many cases (e. g. examples shown at fig. 3), students update the website up to now, even though they are no longer involved in the project and have no obligation to continue to work on it.

Benefits of implementation the inquiry-based activities within the Chain reaction project

Besides the teacher interviews we used additional methods of gaining teachers' feedback: evaluation meetings at the end of each project year and a survey with the help of evaluation questionnaires.

The evaluation meetings were focused on a deep evaluation of various project aspects in the given year. Teachers in groups discussed the overall organization of the project activities and then concentrated on in-school delivery. After separated discussions the groups met and presented their opinions. The view of project organizers was compared with a view of the teachers.

The questionnaires were completed by teachers twice – at the beginning and at the end of the school year. By the first questionnaire we intended to find out expectations of teachers connected with an implementation of inquiry-based activities into their science lessons. At the end of the school year, after incorporating at least one long-term inquiry-based student project during science lessons, all teachers were asked to reflect on the outcomes they and their students gained.

Teachers' view on outcomes gained by the students who had a chance to experience Chain Reaction approaches is shown at fig. 4.

Students' outcomes

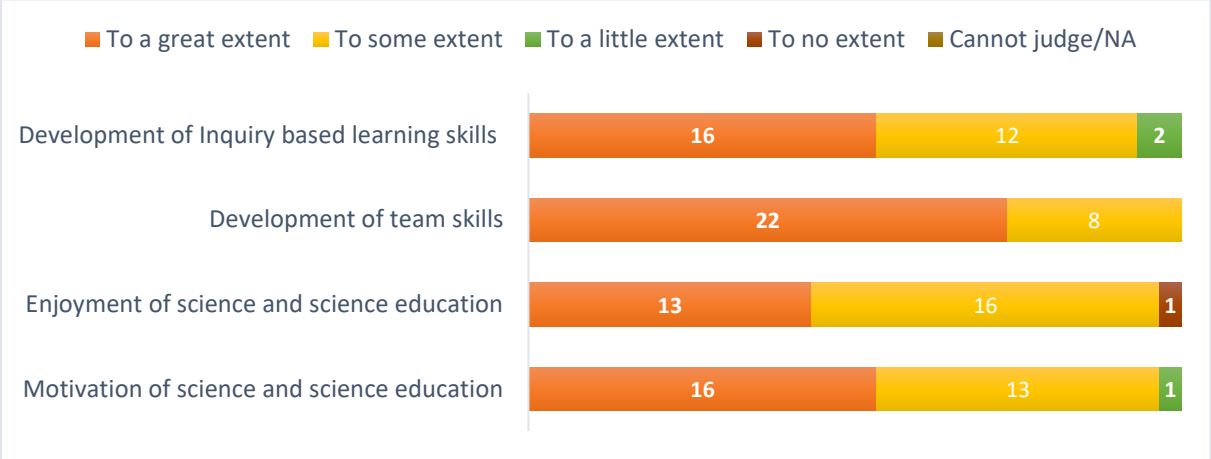

Fig. 4. Students' outcomes after practising inquiry-based activities during a school year

As graph shows teachers have thought that students' outcomes at the end of the school year were very positive. All teachers agreed that the using of inquiry-based activities helped to develop team skills of students. A similar situation was in the case of the development of inquiry-based learning skills, although 100 % of teachers' answers were not positive.

Answers on items about enjoyment and motivation of science and science education were more than satisfactory because, as school practice shows, in addition to developing competences in science it is important to address motivation of science among students. As results show, used activities could contribute not only to the development of scientific competences but also to the increase of students' motivation and enjoyment of science and science education.

The positive impact of the project to students engagement in physics was clearly expressed e.g. by Zuzana Polakova, teacher participating at the Chain Reaction public seminar who said: "*An interest of students to learn physics has increased significantly – the students choose optional physics lessons and physics themes for their projects, they are interested in participation at physics competitions and other physics activities, several students decided to study physics at university*" (Koctúrová, 2016).

Teachers' outcomes

The analysis of teachers' responses to the initial and final questionnaires shows that the teachers went into the project with relatively high expectations. Fig. 5 shows, for example, the level of those expectations in the area of teacher professional development and compares it with the teachers' views on the outcomes in this area. The comparison indicates that teachers' expectations were more or less met. Positive impact of the used inquiry-base activities in the educational process is obvious also from teachers' responses to other questions of the questionnaires.

But implementation of these activities to the lessons was not without complications. During evaluation meetings teachers expressed also a plenty of difficulties they had to cope with during the in-school delivery period.

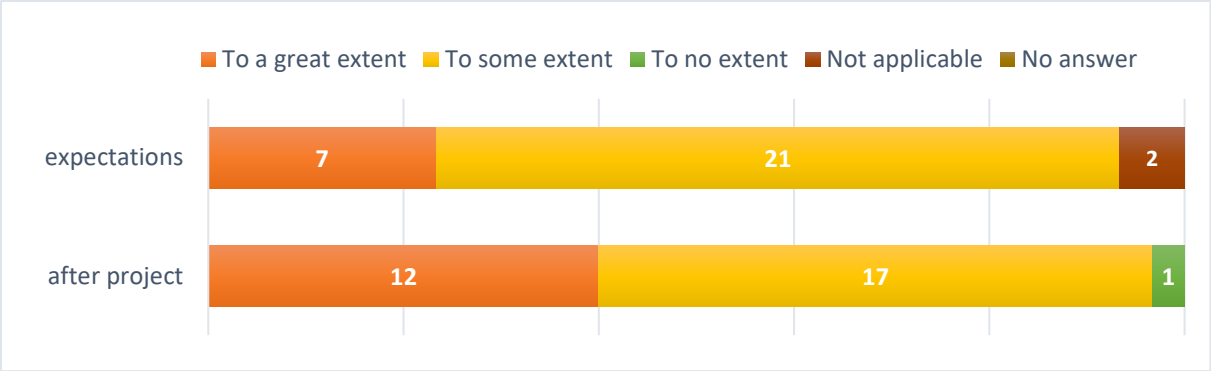

Fig. 5: Teachers' view about an increase of their positive attitude to professional development

As the most serious problem seemed to be the time because the incorporation of student research projects into science subjects program requires too long time. Students had to conduct some experimental work during their free time, after their classes. The conducting of the experimental part of the students' projects in classes with many students was the second important issue for the teachers. Another problem was related to preparation of students for admission procedure to universities. The teachers felt to have a very limited time for inquiry-based activities at physics lessons, because the students wanted/had to be prepared for entrance exams to universities and for school-leaving exams and they needed to have a lot of theoretical knowledge.

Conclusion

The main objective of the activities developed in the Chain Reaction project was to support experimental and investigative work through exciting and realistic situations that link the acquisition of scientific knowledge and skills to the exploration and solving of problem. Inquiry allows students to use the skills, knowledge and experience in a flexible and creative way. Productive work in small groups and the ability to plan their own work motivate students and enable them to understand science research as a human activity. Each of us learns in different ways. Most people just do not learn linearly and inquiry provides them an opportunity to do it in different ways.

As a sample of the activity Comic Website indicates, realization of this activity requires longer time than a few lessons. Therefore, the motivation of students is one of the most important factors, which affect the successful implementation of these activities into the classroom. Another factor influencing the successful implementation of this kind of activities is the application of cross-curricular relationships. For this reason, it is important to take into account the level of knowledge of students from other science subjects to enable successful integration of these activities into the learning process.

Nevertheless, the school practice shows that the character of the inquiry activities strongly supports the intrinsic motivation of students and contributes to their increased interest in sciences also after the project. Precisely prepared inquiry-based activities and set up of appropriate teaching conditions can lead to a significant development of a wide range of students skills and understanding how science work.

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VARIANT TEXTS ACCORDING TO TYPES OF SENSORY PERCEPTION

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Abstract

The paper deals with a problematic of creating variant texts according to a sensory perception. An idea of transcribing text is based on a theory of adaptive learning, which is thoroughly studied at the Department of Information and Communication Technologies. Researchers in this work combined the adaptive approach together with thinking styles introduced by Libor Činka and created four variants of texts of the chosen topics. Then those texts undergone the verification by the students from high school and university, who read them and evaluated them as well as they answered to a prepared set of testing questions. All received data was compared against the replies from the learning style questionnaires VARK and questionnaire by Šimíčková. The paper discovered some differences between the results of VARK and Šimíčková questionnaire, which proved to be slightly more reliable compared to both the results of test questions and the students' own opinion. There were also differences between sensory variants of texts. As expected, the kinesthetic variant proved to be the less effective compared to the rest. It seems that university students accepted the rewritten texts better than high school students too.

Keywords

Variant texts, types of sensory perception, learning style, adaptive instruction.

Introduction

The theory of adaptive learning is being developed at Department of Information and Communication Technologies for last several years. The Barborka4 system was created for the realization of experiments of adaptive teaching. In the beginning of the adaptive education the students start with a questionnaire that measures their learning styles and other characteristics that affect their learning. The aim is to achieve more efficient learning of students and deeper understanding and remembering of information during the education process. (Kostolányová, 2016)

The background of the student population in any university is very diverse. This includes varied socio-economic background, wide ranging ages of students, varied cultural background, prior educational experiences, levels of competency and preparedness, and preferred learning strategies. (Meehan-Andrew, 2009) Effective teaching in such a set up can be difficult and challenging. Teaching is a process of knowledge presentation while learning is often multifactorial and depends on the mindset of each student. (Drago, Wagner, 2004)

Neil Fleming in his landmark article 'I'm different; not dumb: Modes of presentation (V.A.R.K.) in the tertiary classroom' says that people learn in different ways using variety of strategies to convert the educational message into their long term memories. (Prithishkumar, 2014) There is no single best way to teach, but teachers can diversify their teaching styles to cater to the learning styles of each distinctive student. (Becker, 2007) Awareness of learning styles will help educators identify and solve learning problems among students. (Baykan, 2007)

An interesting stimulus for the research was the idea of Libor Činka, who argues that the preferred way of thinking (which can also be understood as a preferred learning style and can be determined on a basis of a questionnaire) in a speech reflected by the frequent occurrence of words associated with the thinking of either visual or auditory, or kinesthetic. You can meet the people who think quite strong in one sense only rarely. A situation where you have to be very attentive in order to identify the preferred way of the speaker's thinking is more common. It is because the language of the speaker contains not always clear identification of the words in his preferred way of thinking.

To test this idea, the four different texts were selected and these texts had no connection to the students' field of study. These texts were subsequently rewritten using the words which Činka has assigned a preferred way of thinking. The questionnaires that are used to detect learning style were also include in the research.

Basic research questions were:

- Can you formulate the text itself according to the learning styles?
- In which way?
- Will this modified text be more understandable and enjoyable for the readers?
- Will the reader with the preferred visual style of thinking be able to remember more due to rewritten and revised text?
- Will the text be easier to read for him? Will it be better understandable?

To fulfill these questions, the choice of proper text was made. Then the texts were rewritten to all sense variants and the time-consuming data collecting started including filling in the questionnaires and testing the texts by students who were reading them. The evaluation of this research brought interesting results.

Sensory Analysis

A group of properties called Sensory Perception describes which form of information students are most comfortable with. The sensory perception in the system Barborka4 is determined by a questionnaire, whose authors are Fleming and Mills (Fleming, 1992), and is also determined by other testing questions from Žáčková (1999) later on modified by Šimíčková. Both

questionnaires try to capture to what extent the students' senses are represented by the different types of sensory perception; verbal, visual, auditory and kinesthetic. Based upon the type of sensory perception the study material is adapted. A positive impact on the rate of learning during the use of adaptive teaching has been confirmed in several dissertations.

Both questionnaires VARK (Murphy, 2014), Šimíčková will be used in order to discover how they both differ in the way of identifying of preferred learning style and to determine how much their data will be similar.

In this research the students completed both questionnaires. After that they were familiarized with the characteristics of each type of sensory perception. Then they should try to determine to which extent they think they have the dominant types of sensory perception. In the conclusion, the results from VARK, Šimíčková and students' opinion will be compared.

The types of sensory perception in the text - the language of the senses

According to Činka (2012), a type of sensory perception in speech is reflected by the frequent occurrence of words associated with the thinking of either visual or auditory, or kinesthetic. Only rarely you can meet people who think strongly in one way. More common is a situation where you have to be very attentive to the preferred type of sensory perception. It cannot be identified, because speaker's language is not always clear in the first hearing and identification of a preferred way of thinking may be misinterpreted.

Visual types frequently used sayings:

- "I do not see any sense."
- "It is clear what you want to show us."
- "Let me show you my vision."
- "I do not see the sense."
- "Let me clarify this idea."

For visual types are important the tables, graphs, sketches.

Auditory types rather hear say:

- "I think it was absolutely consistent."
- "Do I hear you well?"
- "Tell me more."
- "Sounds great!"
- "Let's discuss."

Auditory people respond best to the instructions and information expressed verbally considering written messages or instructions to be less important.

Kinesthetic types express more feelings and emotions:

- "I do not know why it is exciting."
- "I understand how you feel."

- "You hit the nail on the head."
- "You need to fight with that."
- "I'm in a terrible stress."

Based on the above characteristics Činka created a table of words that represent different types of sensory perception, i.e. the language of senses. Red words represent a visual, auditory a blue, green a kinesthetic and black a neutral (see Fig. 1, in Czech).

vidět	myslet	oznámit	znát	odkrýt	obtížný	pamatovat	drsný
aspekt	rozhodnout	volat	vliv	oko	aktivní	vědět	pochopit
iluze	ječet	soudit	klepy	okruh	nutit	nesouhlasím	pevný
grafický	hovořit	hodnotit	klapnout	vymezit	narazit	panický	rozeznávat
ilustrovat	hluk	harmonie	konstatovat	obraz	mnout	napadnout	uznávat
malovat	hlasitý	formulovat	naladit	krátkozraký	emocionální	řídit	navštěvovat
odhalit	jevit se	meditovat	jasný	načrtnout	chladný	chopit se	proces
slyšet	image	vědomý	blýsknout se	dotazovat	citlivý	držet	učit
akcent	nápadný	dívat se	pestrý	doslech	brousit	povolit	dráždit
alarmovat	věřit	barvy	vyzkoušet	výmluvný	bolavý	motivovat	dotknout se
bouřlivý	řešit	horizont	připravit	diskutovat	bezcitný	rozumět	dojatý

Fig. 1: Words of sensory perception (Činka, 2012, in Czech)

Design of the research

We decided to test the theory of words of sensory perception in practice. We conducted a selection of four texts of different topics that we rewrote using words of sensory perception. The four variants were created (verbal, auditory, kinesthetic, auditory) for each text. Then we let the students read them. A student read four texts that were thematically and sensory variant different that every student has worked with four variants and four themes. After reading them each student completed a questionnaire with knowledge questions from the text and further questions regarding how he read the text and how he understood it. Each respondent also completed in the time span of about one month the questionnaires to determine the learning style VARK and Šimíčková version. The validity and reliability of VARK questionnaire was determined in earlier research (Leite, 2010, Fitkov-Norris, 2015, Thepsatitporn, 2016). After completing all these questionnaires, the processing and evaluation questionnaires followed.

The research group

The research sample consisted of 35 respondents. The 14 students were from high school and 21 university students of Information and communication technology in education.

Selection and processing of variant texts

The chosen texts had no connection to the field of study of all students. The topics were not covered neither on high school nor university. Table. 1 describes the content of selected texts.

Topic No. 1 Blood Groups	Text deals with the discovery of different blood groups, their history and influence on catering for different types of blood groups.

Topic No. 2 Lord of Lightning	Very short biography of Nicola Tesla's life and inventions.
Topic No. 3 Pond in the Garden	Describes the process of building a pond in the garden. By digging a trench through the film location, making the pond after placing a pump and filter.
Topic No. 4 Golden Ratio	The construction of the golden section in mathematics and its practical use in practice.

Tab. 1: Text topics

Respondents completed the two electronic questionnaires for the purpose of learning (codename RVAK, ŠIMI2) and read four texts on different subject and sensory perception. At the end, they filled in a questionnaire to read text.

Each topic was written on one side of an A4 sheet that it did not take a lot of time for reading the texts. The texts were rewritten using the words that according Činka represented some kind of sensory perception. Činka speaks about three types of variants of words - auditory, visual, and kinesthetic. The original text was considered a verbal variant. Here is an example of the following rewritten text of the "Lord of Lightning." Colored words are transposed ones (the translation from the Czech):

Verbal variant - the original text:

"Nikola Tesla, who at the peak of his career earned the nickname the Lord of Lightning, was born during the storm. It happened on the night of 9 to 10 July 1856 in the Serbian village of Smiljan. Even as a child he had a great imagination and an excellent memory. Gradually, he learned six languages, he studied mathematics and physics at the Universities of Graz in Austria, and Prague and Budapest and during the work in the telegraph company he began to deal with the principle of alternating current. "

Visual variant – the rewritten text:

"Nikola Tesla, who at the peak of his career was marked as the Lord of Lightning, was born symbolically during the storm. It happened on the night of 9 to 10 July 1856 in the Serbian village of Smiljan. Even as a child he was distinguished by a great imagination and an excellent memory. Gradually, he learned colorful set of six languages, he studied mathematics and physics at the Universities of Graz in Austria, and Prague and Budapest and during the work in the telegraph company he began to clarify the principle of alternating current. "

Auditory variant – the rewritten text:

"Nikola Tesla, who at the peak of his career was called the Lord of Lightning, was born during the storm. It happened on the night of 9 to 10 July 1856 in the Serbian village of Smiljan. Even as a child he had a great imagination and an excellent memory. Gradually, he learned six languages, he studied mathematics and physics at the Universities of Graz in Austria, and

Prague and Budapest and during the work in the telegraph company he began to deal with the principle of alternating current. "

Kinesthetic variant – the rewritten text:

"Nikola Tesla, who at the peak of his career earned the nickname the Lord of Lightning, was born during the storm. It happened on the night of 9 to 10 July 1856 in the Serbian village of Smiljan. Even as a child he had a great imagination and an excellent memory. Gradually, he learned six languages, he studied mathematics and physics at the Universities of Graz in Austria, and Prague and Budapest and during the work in the telegraph company he focused on the principle of alternating current. "

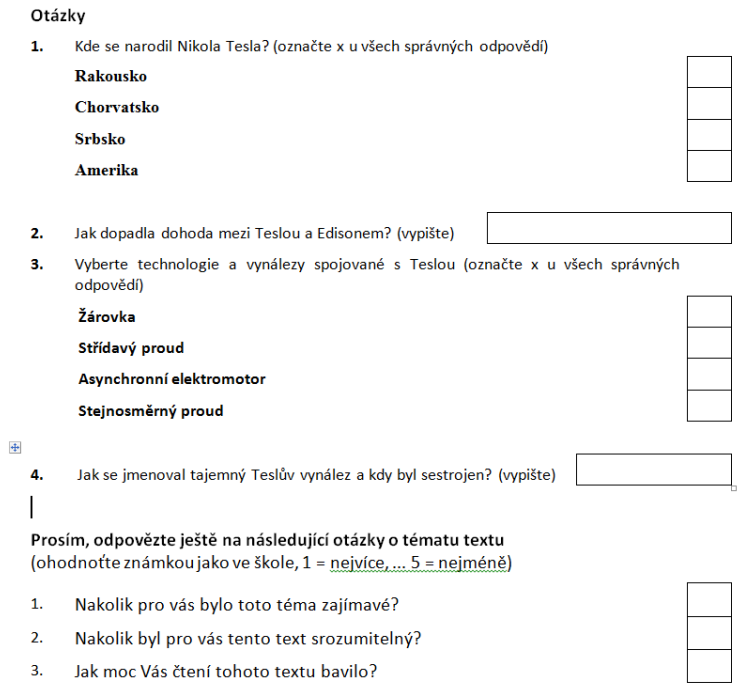
In this way, all the texts were transcribed in all selected topics.

Questionnaire design

For each topic, a questionnaire was created which tested the level of acquired knowledge. Furthermore, the questionnaire contained three questions on the interest, attraction and clarity of the text. These three questions were the same in all texts:

- How much interesting this topic was?
- How much clear the text was?
- How much have you enjoyed reading this text?

See a questionnaire bellow (in Czech).



Otázky

1. Kde se narodil Nikola Tesla? (označte x u všech správných odpovědí)
   - **Rakousko** ☐
   - **Chorvatsko** ☐
   - **Srbsko** ☐
   - **Amerika** ☐
2. Jak dopadla dohoda mezi Teslou a Edisonem? (vypište) ☐
3. Vyberte technologie a vynálezy spojované s Teslou (označte x u všech správných odpovědí)
   - **Žárovka** ☐
   - **Střídavý proud** ☐
   - **Asynchronní elektromotor** ☐
   - **Stejnosměrný proud** ☐
4. Jak se jmenoval tajemný Teslův vynález a kdy byl sestrojen? (vypište) ☐

Prosím, odpovězte ještě na následující otázky o tématu textu
(ohodnoťte známkou jako ve škole, 1 = nejvíce, … 5 = nejméně)

1. Nakolik pro vás bylo toto téma zajímavé? ☐
2. Nakolik byl pro vás tento text srozumitelný? ☐
3. Jak moc Vás čtení tohoto textu bavilo? ☐

Fig. 2: Questionnaire for text variant (in Czech)

Questionnaires on learning styles

Each respondent questionnaires also filled in a questionnaire to determine the learning style in addition to variant texts. There were two questionnaires filled out by respondents given at least two weeks' gap. Questions from both questionnaires are used in the system Barborka4 to identify the learning style of students:

- VARK - a questionnaire composed of 16 questions, used worldwide to determine the learning style. Each question offers the possibility of dealing with a particular situation in one of four styles (visual, auditory, verbal, kinesthetic). The respondent may choose more than one answer to a question. This questionnaire is also used for purposes of online education (Zapalska, 2006).
- Questionnaire from Šimíčková - contains 40 questions. Always 10 questions testing the specific learning style. The questions are worded notification sentence and respondent should determine how often to described life situation (often, sometimes, rarely).

After the questionnaire that respondents completed a set of another questions was added to determine what learning style are according to them after they have been displayed characteristics of different styles.

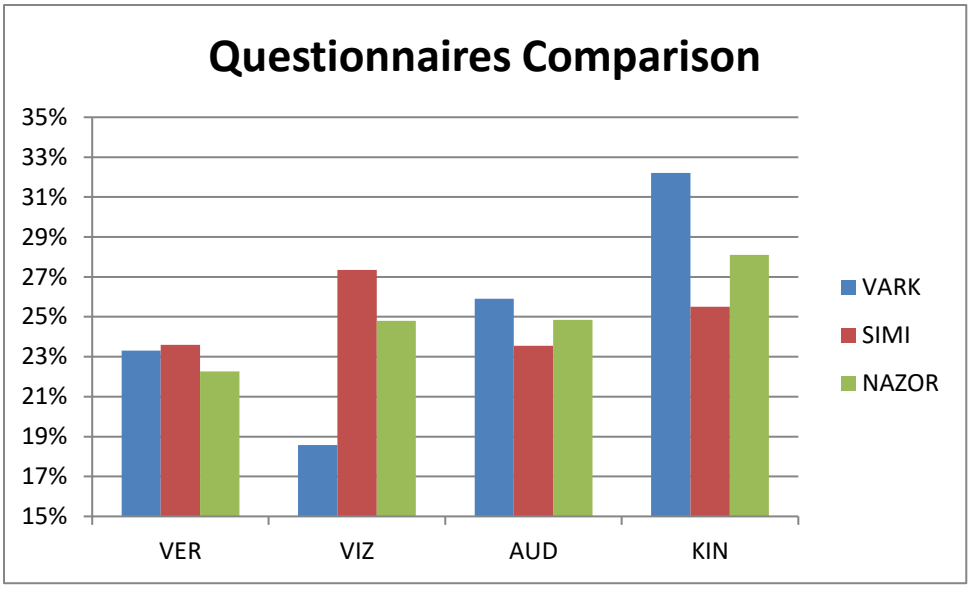
Process of reading texts and completing the questionnaires

Two months before the reading of variant texts the respondents filled in both questionnaires. Between both questionnaires there was at least two weeks' delay. After that the students came to read the four variant texts. Each of students read four different topics in four different variants, but four in total (the students had the different texts in different variants chosen randomly, but it was made sure that each of them had different sensory variant and not repeating topic). The reading all four texts took an hour in average.

Then the all data was gathered into the spreadsheet and evaluated.

Results – The learning styles

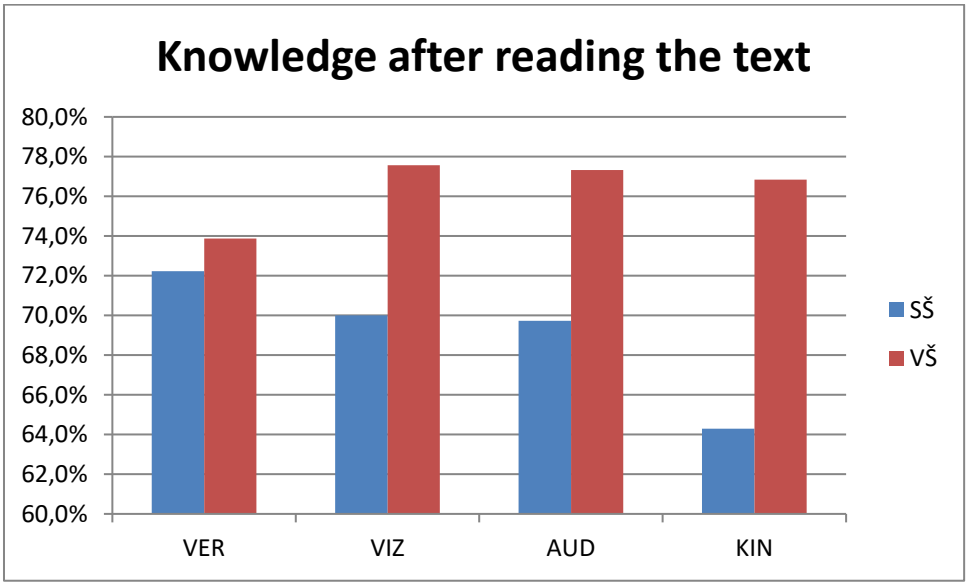
The graph no. 1 shows the comparison of results of two questionnaires on learning styles (VARK, Šimíčková) and opinions (NAZOR) of respondents. For comparison, the questionnaire was calculated as the percentage of identified style of each respondent. The graph shows the average proportion of learning styles of all respondents. There is a significant variation evident between visual and kinesthetic style in VARK questionnaire. Šimíčková version more corresponds to the views of respondents.



Graph 1: Questionnaires Comparison

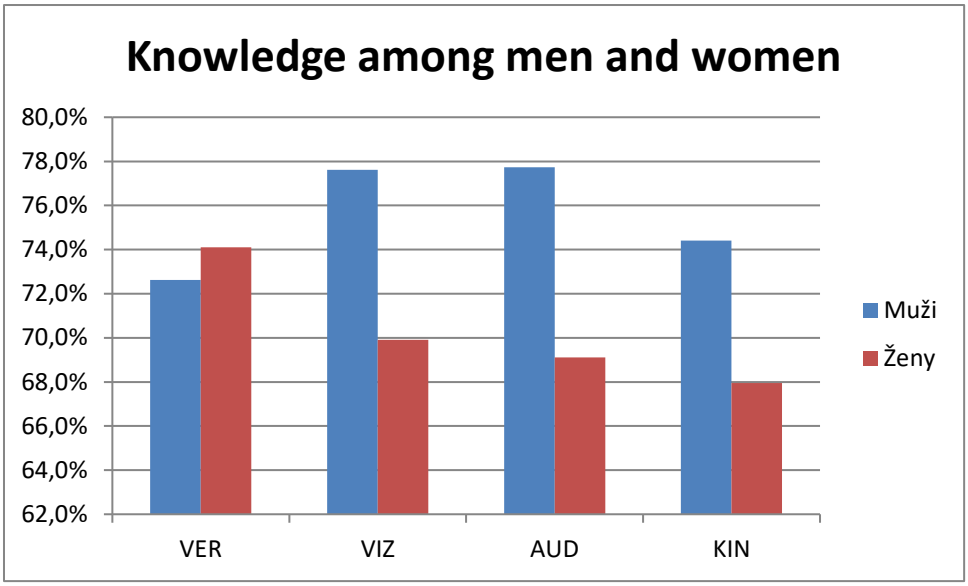
Results - Knowledge after reading the text

The degree of knowledge gained from the read texts was calculated as the percentage of correct answers. The graph no. 2 shows that high school students (SŠ) have a lower success rate for all variants of the text. The smallest success has kinesthetic variant texts. It is possible to argue that the modification of the original text in sensory variant did not suit to high school students, but university students (VŠ) have proven some increase of knowledge in the rewritten texts variations.



Graph 2: Knowledge after reading the text

The graph no. 3 shows the difference of knowledge among men (Muži, blue) and women (Ženy, red). Women seem to be better at verbal texts variations. Knowledge of men are higher in visual, auditory and kinesthetic variant texts.



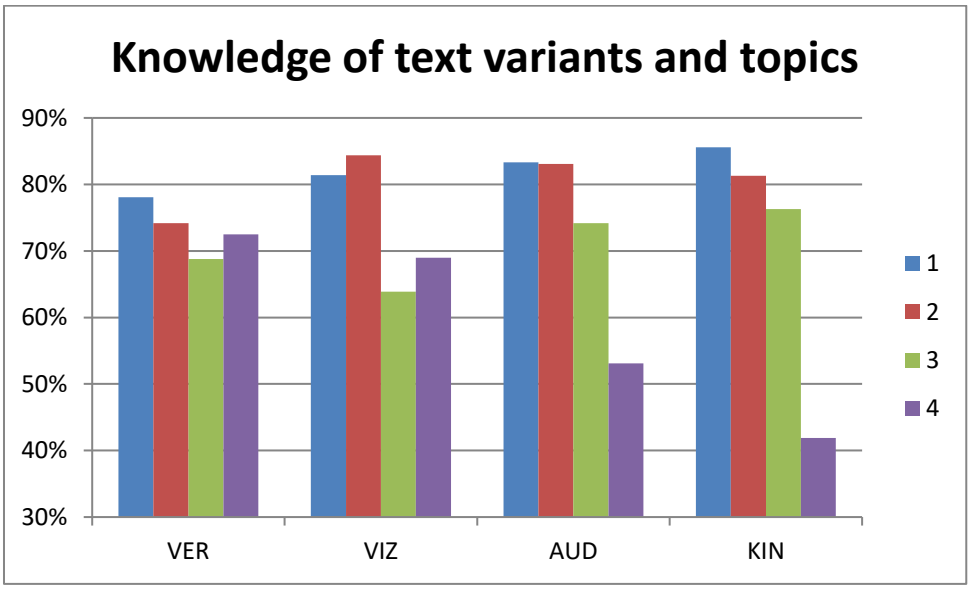
Graph 3: Knowledge among men and women

The table no. 2 shows the overall average students' knowledge according to variants and topics. There is not much difference in knowledge for each variant text. It seems that the modified texts do not significantly improve the percentage of acquired knowledge. On the other hand, the topic seems to be the factor changing the received knowledge.

Knowledge – Variants		Knowledge – Topics	
Verbal	73 %	Topic No. 1 Blood Groups	82 %
Visual	75 %	Topic No. 2 Lord of Lightning	81 %
Auditory	73 %	Topic No. 3 Pond in the Garden	71 %
Kinesthetic	71 %	Topic No. 4 Golden Ratio	59 %

Tab 2: Knowledge in Variants and Topics

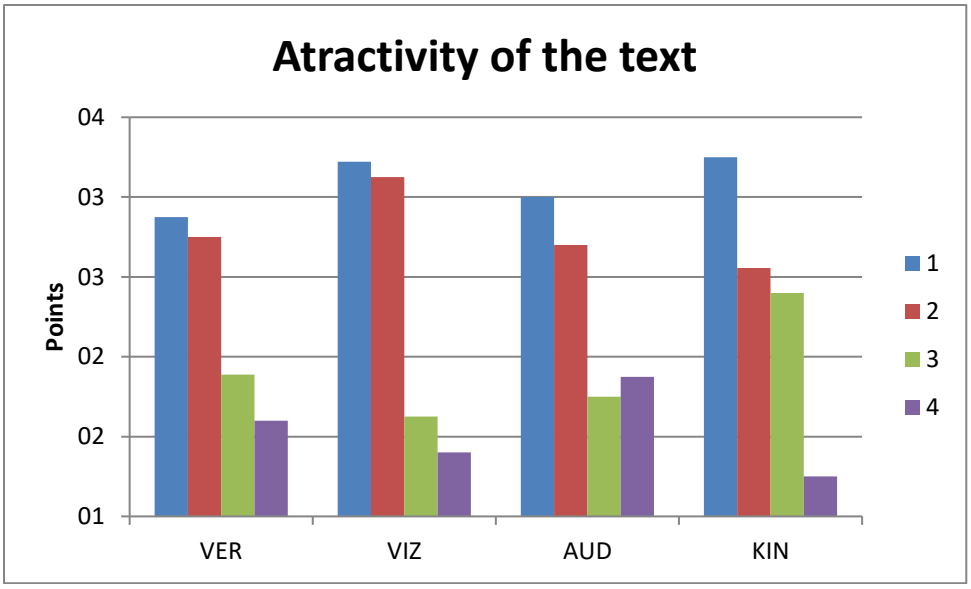
Graph no. 3 displays the percentage of correct answers in a knowledge test by topics and texts variations. The most balanced versions are the original texts – verbal variant. There were higher results in knowledge of the rewritten texts at the topics 1 and 2. A significant negative impact had the auditory and kinesthetic variant of topic 4, which significantly decreased percentage of students who correctly answered the test questions.



Graph 4: Knowledge of text variants and topics

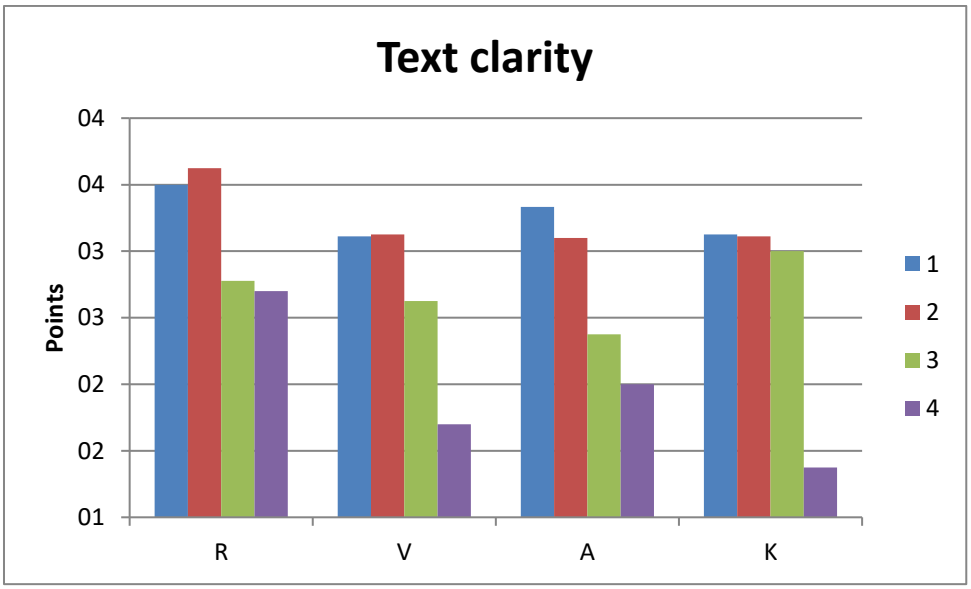
Answers to the evaluation questions

The graph no. 4 shows the average number of points to the question: " How much interesting this topic was?" 0 points means the least, 4 the most. The most appreciated text was the Blood groups in all variants where in all variants the attraction grew a little. The following was the topic 2 the Lord of lightning, which was the most interesting in the visual variant. The remaining two topics were less attractive, where the worst ended the topic 4 in kinesthetic variant. The topic 3 "Pond in the Garden" was the most interesting for students in the kinesthetic variant. These results correlated to some extent with the results in the graph no. 3 and the text interestingness could be the cause of success in the knowledge test questions.



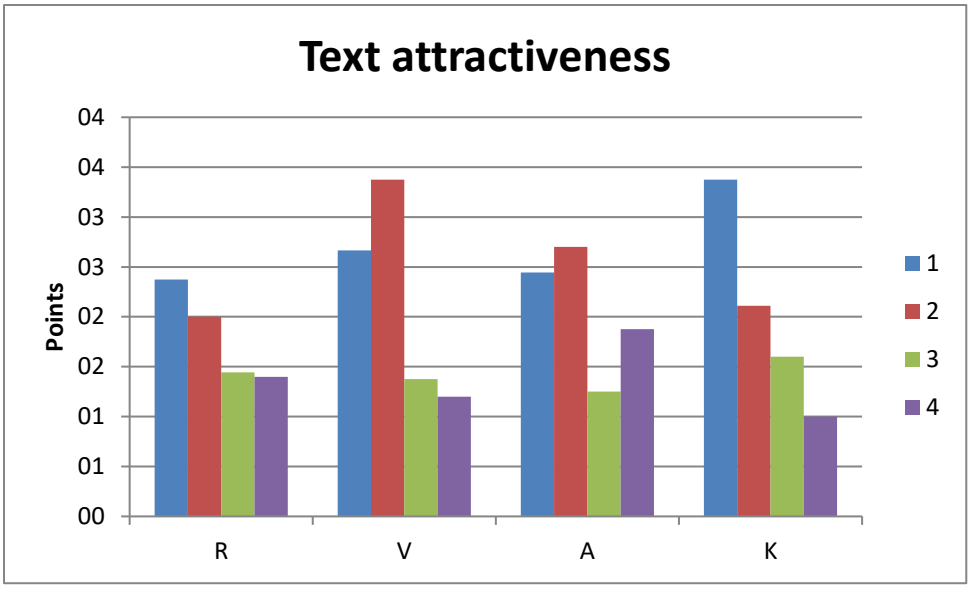
Graph 5: Attraction of the text

The graph no. 5 deals with the question: " How much clear the text was?" Here we see clearly that all the topics were clearest the most for the students in the original verbal variant with an exception of the kinesthetic topic 3, which the only seemed clearer than the original version.



Graph 6: Text clarity

The rest of results is represented by the question " How much have you enjoyed reading this text?" in the graph no. 6. There has been an increase in an attractiveness from its original version in the topics 1 and 2. The most students enjoyed reading topic 2 in the visual variant and topic 1 in the kinesthetic variant. It seems that swapping sensory words can lead to greater attractiveness of the text.



Graph 7: Text attractiveness

Percentage of the responses in variant texts due to the results of the VARK questionnaire

Now we compare how students have been successful in the knowledge test questions depending on what were the predominant learning style based on the VARK questionnaire. Table no. 3 is calculated the percentage of correct answers for those students who had the strongest learning style according to the test. The second column is the number of these students. The table does not represent all, since the four students were excluded who had two equally strong learning styles. Students with the identified dominant visual style of learning had the highest success rates in the verbal text and vice versa with the detected verbal style were more successful at visual text. For the auditory and kinesthetic styles were results equal. But it must be said that there was a small sample of students and differences in the proportion of correct answers are not much statistically significant, therefore we cannot generalize conclusion based on this results.

VARK questionnaire	The number of students	R	V	A	K
V	3	**90.0 %**	65.8 %	79.6 %	85.4 %
A	6	62.1 %	65.0 %	**70.2 %**	66.9 %
R	6	76.3 %	**81.7 %**	71.3 %	53.8 %
K	16	71.3 %	75.6 %	74.1 %	**76.1 %**

Tab 3: VARK and text variants

Conclusion

The paper describes the research, which was based on the idea of Libor Činka and his thoughts about the types of sensory perception in the text, because his division of sensory perception of the text is the same as learning styles, which is detected by the questionnaires VARK and questions by Šimíčková. We have redesigned according to the proposed procedures the four

different texts in the three sensory variants (visual, auditory, kinesthetic) and the original one was labeled as verbal. The research involved 35 students from the high school and university.

Firstly, students completed the questionnaires on learning styles. The results of the analysis of the findings of the questionnaires pointed out to a contradiction in the results of the questionnaire VARK and the opinions of students with visual and kinesthetic learning style. Questions by Šimíčková agreed more to a students' view of their own learning style (see graph 1).

Another area of the research was the memorized knowledge of the texts acquired by reading them. A significant difference between secondary school and university has shown, where the university students had a greater degree of knowledge in the modified variants of texts (see graph 2). If we take into account the overall performance in the level of knowledge, according to the sensory texts variation, the rewritten texts seem to not affect the acquired knowledge of students and all variants have the proportion of correct answers over 70 %. The difference between the smallest and the largest proportion of correct answers is 4 %. But it is different about at the topics of texts, where appeared a significant impact on their level of knowledge according to what topic the students read. The difference between the best and the worst percentage of correct answers is 23 % (see graph 4). Based on these results we cannot confirm the correctness of Činka's ideas and the memorization rate is primarily affected by the theme of the text than what words are used in the text.

According to the evaluation questions (subjective feelings of students on the interest, clarity and attractiveness of the texts) confirms previous findings on the rate of acquired knowledge and based on that we know that the least interesting, understandable and boring text has the lowest successful rate. But some impact of variant texts still can be observed. If the rewritten (V, A, K) and original texts are compared the interestingness and attractiveness have increased in average. On the contrary the clarity of rewritten text variations has fallen.

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EDMODO: INNOVATIVE ONLINE EDUCATIONAL TOOLS

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The emergence of new technologies has increased the interest in online education. In addition to regular school systems, new education platforms such as *Web-based classroom tools, Web-based learning technologies, Social Learning Community, Web-based learning networks, Educational Social Network Sites, etc.* are emerging. Those enable sharing, cooperation and new forms of synchronous and asynchronous communication. Thanks to their popularity, the number of integrated functions and the fact that they are accessible from the Web interface, the educational social networks appear to be the optimal and complex solution to instruction in an online environment in different school types and at different school levels. It was the popularity of social networks that prompted teachers to start looking for ways to implement them into the school environment (Balasubramanian et al., 2014). The following are some of the community education platforms: Schoology, iTřída, Clever, Classroom 2.0, Twiducate, Sophia, Edmodo, etc. This paper is aimed at the Edmodo community platform.

Edmodo is a free worldwide education network aimed primarily at primary and secondary education (the K-12 sector), but also at the university environment (Murar, 2015). It is popular abroad. Its interface is similar to Facebook (see *Fig. 1*). The similarity of both networks makes orientation in the environment easier.

The fact that Edmodo supports Windows, Android and iOS operating systems makes it compatible with the majority of mobile devices. As a result, the BYOD (*Bring Your Own Device*) concept can be applied. The teacher, student and parent (who can follow their child's activity) can access the network. Furthermore, the teacher specifies their position in the network by assigning roles (*Administrator, Principal, Teacher, Librarian, Tech Coordinator, Counselor, Coach* and *Tutor*). The user, most often in the role of Administrator, can create the school's admin account, making the following functions accessible:

- Analytics Module – an analytical device measuring the activity and involvement of users,
- Secure Domain – creation of a school subdomain, e.g. *schoolname.edmodo.com*,
- PD Tools – Teacher Badges, creation of Professional Learning Communities (PLC).

Edmodo, and a number of other platforms, is constantly being developed. One of the important changes that increased the effectiveness of Edmodo was making the platform compatible with Google Drive, One Drive and Microsoft (May, 2016). As a result, one can now log in to the network through their Google account as well as their school/company Office 365 account. Moreover, Microsoft Word, Excel and PowerPoint have become freely available, improving cooperation (see Office Online).

Place for Education and Cooperation

Students can not only share the created files with others within the group, but also work together on editing the content. To save files the students use so-called Backpack (the teachers use so-called Library), i.e. a virtual flash drive on which they can save an unlimited amount of files. However, there is the so-called upload limit, i.e. the amount of data *uploaded to* or *downloaded from* the storage is limited. For instance, files uploaded from *Backpack* to the virtual classroom's *wall* cannot be larger than 100MB. However, files uploaded from Google Drive can be larger than that.

Edmodo not only enables schools to create their own communities, but also provides a space for managed instruction in an online environment. The following are the most useful tools:

- *Note* – uploading notes and study materials to the virtual classroom's wall,
- *Assignment* – a task management tool,
- *Quiz* – a tool for creating quizzes and tests,
- *Poll* – a tool for creating polls,
- *Edmodo Planner* – a shared calendar,
- *Office Online* – a tool for Word, PowerPoint and Excel applications,
- *Progress* – a tool for monitoring the student's progress (Grade/Badge)
- *Spotlight Apps* – a shared storage of available applications.

Edmodo has a number of features that encourage group discussion, provide feedback, manage tasks, assign badges and/or monitor the student's progress. Moreover, it also allows for cooperation of teams from different schools and enables teachers to create professional relationships (creating the *Personal Learning Network*). It also appears to be the optimal solution to the problem of distinguishing between the personal and professional identity of the teacher.

The main features can be seen in Fig 2.

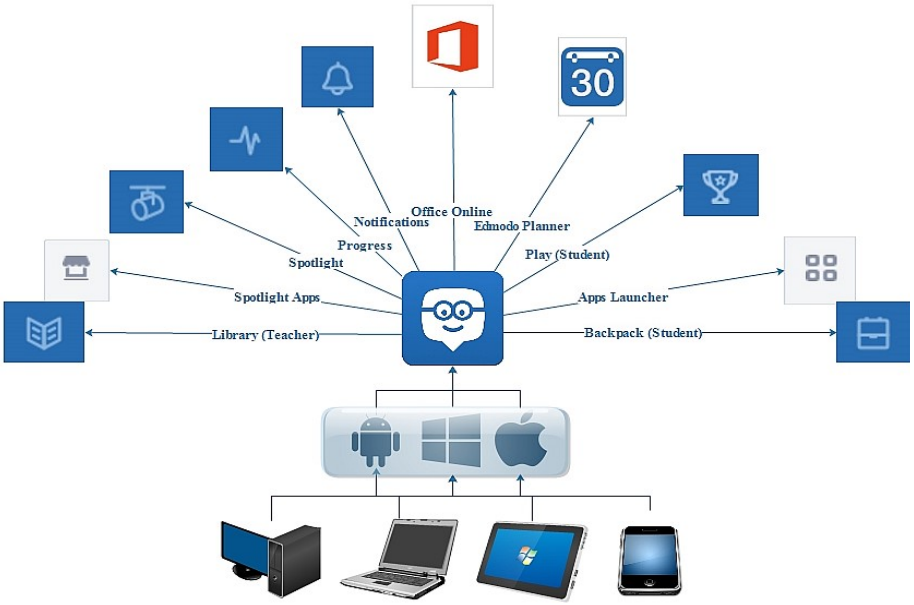

Fig. 2: Edmodo – educational space

Spotlight Apps enables every teacher, based on their personal preference and/or professional qualification, to not only adjust the range of tools, but also to add the so-called third party tools.

Some of them, however, must be paid for. The range of tools is expanded on the basis of the user published content. By assigning an application to the particular workgroup's library, the teacher specifies the tools the group can use in their work.

The Edmodo environment features a number of gamification elements which should motivate both the student and the teacher. Edmodo supports the following:

- Badge assignment (allows for the creation of new badges),
- Point collecting,
- Monitoring the user's level (from the point of view of both the student and the teacher).

Furthermore, Edmodo enables its users to participate in conferences and webinars organized within or supported by the platform. The users are notified of the event (e.g. EdmodoCon – Edmodo's Annual Educator Conference, Edfinity, etc.) by an invitation posted on the wall.

Edmodo supports not only the creation of individual accounts for individual courses, but also the creation of communities that include both teachers and students not only from the given school, but from the entire district, thus encouraging cooperation and the creation of a learning-friendly and goal-oriented environment.

Environment Privacy

Edmodo is a closed, private education platform with a number of privacy features such as (https://www.edmodo.com/privacy):

- The student needs to provide minimum personally identifiable information to create an account,
- Edmodo does not collect geo-location tracking information,
- Edmodo does not rent or sell student information to third parties for marketing or advertising purposes,
- Parents can create accounts to view their child's activity,
- Students cannot privately communicate with each other (only public communication within the group is allowed).

The student activity is supervised by the teacher, who has a special role in the group. The teacher creates a virtual group (classroom), invites students to participate in it (via email or by sending them a password) and monitors their activity. The teacher also controls the group (grants access to the environment, divides students into groups, deals with forgotten passwords – generates new ones, etc.). Parental consent is required before Edmodo can be used by students under the age of eighteen.

Conclusion

The school environment allows for the creation and development of virtual communities. Edmodo is an available social and communication platform which provides opportunities for the creation of communities within managed instruction and communities that include both teachers and students not only from the given school, but from the entire district. Moreover, it also connects both students and teachers with people and resources needed to reach their full educational potential. Thanks to the number of integrated features, safety and the fact that it is user-friendly and free of charge, Edmodo is drawing the attention of the Czech teachers.

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