Teaching of science subjects

in higher & highest education

the monograph edited by

Małgorzata Nodzyńska & Wioleta Kopek-Putała

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Introduction

While teaching science subjects at high school and university, teachers are already dealing with students older than 12 years old and as such, according to Piaget's Theory, capable of "formal operations".

At this stage of intellectual development students are capable of reasoning by formulation of hypotheses that are confirmed only by theoretical analysis.

Subsequently, students are engaging in scientific thought process and this can be seen in their ability to solve complex verbal tasks and hypothetical problems as well as maturation of cognitive structures. That is why teaching students at this stage of education should resemble those processes and should be based on independent acquisition of knowledge. We could even go further and conclude that the main role of the teacher at this stage of intellectual development of students is to give them opportunities to learn independently. Education should be treated as individual "quest for knowledge" and search for answers, beliefs. This process should be stimulated by questions posed by a teacher or as a result of individual curiosity.

In this monograph there are described theoretical and practical solutions for teaching students at high school and university stages of education. These methods come from following countries: Albania, Canada, Czech Republic, Italy, Lithuania, Poland, United Kingdom, Slovakia, Slovenia. Broad range of topics and different approaches to didactics at high school/university grants the readers with wide spectrum of issues encountered in science subjects didactics.

Małgorzata Nodzyńska, Wioleta Kopek Putała

Educational means for development of complex scientific thinking

Introduction

Scientific thinking could be defined as knowledge seeking (Kuhn, 2010). This definition encompasses any instance of purposeful thinking that has the objective of enhancing the seeker's knowledge. One consequence that follows from this definition is that scientific thinking is a skill that the students can gain. This skill can be referred to as scientific understanding. When conditions are favourable, the process of scientific thinking may lead to scientific understanding as its product. Indeed, it is the desire for scientific understanding – for explanation – that drives the process of scientific thinking (Kuhn, 2010).

The distinction between scientific thinking and scientific understanding is an important one, since there has arisen in recent years an extensive literature on student's developing understanding in the domains of science. Children construct implicit theories that enable them to make sense of and organize their experience from their earliest years. These early theories are most often incorrect (misconceptions), as well as incomplete (preconceptions). In a process that has come to be referred to as conceptual change, these theories are revised when new evidence has been encountered. Knowledge acquisition is not the accumulation of isolated bits of knowledge, but rather the process of conceptual development (Kuhn, 2010).

The context and purpose of the framework

Focus of the science education is not to memorize words but to understand their meaning and thus acquire new terms. This is the beginning of creating the conceptual knowledge (Blasbag & Arroio, 2012). The knowledge of concepts demands interdisciplinary approach in not only natural sciences but also mathematics and other disciplines. This is also demanded by the advancement of society in complex and interdisciplinary problem-solving. The development of education in areas of science, mathematics and technical disciplines has to reflect these demands.

The program statements of EU determined the educational outputs that were included in national curricular documents of many European states. These outputs highlight development of competencies and skills that are a part of scientific literacy.

The requirements mentioned earlier in the text can be fulfilled by creating the educational means for simultaneous development of chemical and mathematical thinking, which could also be applied to other natural sciences. This article describes the background of the research on the current state of student's approach to the tasks requiring interdisciplinary skills. It also includes examples of educational tasks and complex problem-solving connecting theoretical science knowledge and mathematical principles.

Theoretical basis and methodology

Modelling in chemistry, which is the first example of connection of science and mathematics, can be defined in two ways. For chemistry, the usual way is to define it as simplified representation of a phenomenon showing those characteristics that are important according to the intention of a model. Model can also be seen as a formal expression of an inquired phenomenon, e.g. system of linear equations (Klimeš, 2005).

These definitions imply that there is a strong connection between mathematics and natural sciences. In order to understand this bond of natural sciences and mathematics it is necessary to review the literature and parts of curricular documents of Czech and Slovak republic concerning interdisciplinary approach to teaching chemistry and mathematics and chemical modelling and visualisation which is very closely connected to planimetry and stereometry.

Problems of chemical modelling have especially interested researchers all over the world since the first half of the 20th century. The proof can be found in many articles in the Journal of Chemical Education (e.g. Pouleur, 1932; Robey, 1935; Hazelhurst & Neville, 1935; Campbell, 1948; Wiswesser, 1948; Lambert, 1957; Meyers, 1958; Anker, 1959; Godfrey, 1959; Brumlik, 1961) (American chemical society, 2015).

In "Visualisation in chemistry and chemistry education" (2012) polish author M. Nodzyńska analyses the term image. The image had a cultural importance from prehistory of mankind. Another purpose of image is to show and deliver information. Any visual material must be put into context, described and explained to the receiver in order to complete its' goal effectively. In her monography the author evaluates different types of chemical models used in education. The study puts an emphasis on misconceptions that can emerge from using certain type of model. According to the author, a possible solution to a problem of teaching about chemical structure could be the implementation of quantum mechanics from the beginning of chemical education. Current approach can lead to many misconceptions in the minds of pupils in lower education. These misconceptions have to be rebuilt into the right concepts in high school education, therefore professor Nodzyńska suggests a new approach to education: to implement the knowledge of quantum mechanics in an appropriate way into education in primary schools.

When we talk about using chemical modelling in education we cannot omit student chemical modelling. This means creating chemical models by students.

For the students to be able to do this activity they have to use mathematical apparatus – mostly the knowledge of geometry and its'part stereometry.

M. Bílek (et al., 2007) defines a skill of visual literacy as a group of visual competencies that can be developed using eyesight and other senses. It demands skills to interpret and transform visual and symbolic materials into verbal and vice versa and also to gain and evaluate visual information from a visual material. This definition implies that for the work with visual materials it is necessary to cooperate with mathematical logic, abstract and symbolic thinking. The monography also deals with usage of ICT in modelling in chemistry. It implies that the teacher has to use mathematical principles when creating models in chemistry in a comprehensible form for students.

Currently, authors who write about similar problems, deal with interdisciplinary connections between science and mathematics only marginally (e.g. Slavík, Grégr et al., 2014; Madyal, 2015; Szarka, 2014).

The next part of literature research deals with education objectives, expected outcomes and content of curricular documents especially in the area of science and mathematics in Czech and Slovak republic. As a result of this research of framework and school educational programs it became apparent that content of education in grammar schools does not sufficiently fulfil the interdisciplinary educational objectives set by curriculum. Literature reviews gave us a fixed idea about the areas in chemical and mathematical knowledge that could be connected. In these areas it is possible to create educational tasks that will harness from this connection. For these tasks to be the most effective we have to conduct a research to determine, which parts of these selected areas are the most problematic or even if they are a problem at all.

Our research has been conducted in two main ways. The first part was conducted by a team of Šulcová, Cífková in the years 2014 – 2015 in a form of extensive testing in chemistry among high school students. The results were described and analysed in detail in the thesis „The level of knowledge and skills in chemistry among secondary school students" (Cífková, 2015). The test authors and teachers gained 1079 completed tests, next during 2016, we added 162 more completed tests. These tests were prepared as a tool to verify the overall knowledge of chemistry among the high school students. Due to this not all of the tasks require the usage of mathematical phenomena. So only some of the testing tasks were subjected to the statistical item analysis. In the test of general chemistry there were six tasks that demanded usage of a mathematical principle, in the inorganic chemistry there were two appropriate tasks, both of test in organic chemistry and biochemistry contained three tasks fitting our demands. Therefore fourteen of the tasks were analysed in detail to exactly determine problematic areas.

Second part of our research consists of interviews with the teachers of chemistry, other natural sciences and mathematics. They have been interviewed since 2016. The teachers are asked for example about using mathematical principles during solving of science tasks, which materials are at their disposal or whether the students are able to use these principles effectively. These interviews are still in progress.

Research in the area of using mathematical principles in chemistry according to the students' test results and the opinions of teachers is leading us to creation of new materials and resources that will support this interdisciplinary approach to education. For development of complex scientific thinking it is necessary to use the mathematical and logical principles to find the solutions of scientific tasks. The effectiveness of created materials for connecting mathematics and chemistry is continuously verified in practical grammar school education.

Proposals and results

Problematic areas and tasks with interdisciplinary elements in chemistry, mathematics and science were selected based on the results of the research mentioned before. Students have got the most difficulties applying algebraic calculations in chemistry, use direct and inverse proportion, solving equations, expressing the unknown of a formula of dependence between chemical quantities. Another area of concern is the spatial imagination, geometry and stereometry and the resulting arrangement of atoms in spatial structures and shapes of molecules. The test results have also shown that the students have many difficulties in chemical analytical tasks that require logical thinking. They interpret information from graphs and tables incorrectly. It is very challenging for students to plot measured values into graphs and to evaluate them statistically. The same results were also confirmed by the research of the team lead by professor Cídlová (2015). Reciprocity is an important requirement for high-quality interdisciplinary tasks. The functional analysis emphasizes extensive background of chemistry for the development of theoretical mathematical skills. Students are able to plot a graph of measured values acquired during chemical experiments in the laboratory, but the challenge still remains in revealing the mathematical rule of functional dependence.

Therefore, four major areas of mathematics emerged from the research: geometry, functional analysis, calculations and mathematical statistics. The selected tasks that will be shown in this text are connecting these areas with phenomena of chemistry that either uses them or are able to explain them better.

The knowledge of planimetry (planar geometry) and stereometry (spatial geometry) can aid in discovering and explaining regularities in chemical structure. Students need to create models during their inquiry about chemical structure. Figure 1 shows two approaches to modelling a face centred cubic crystal structure. The first is classical modelling using paper, scissors and tape (Ivan & Šulcová, 2014). The second one is a model created using a mathematical software Geogebra 5.0.

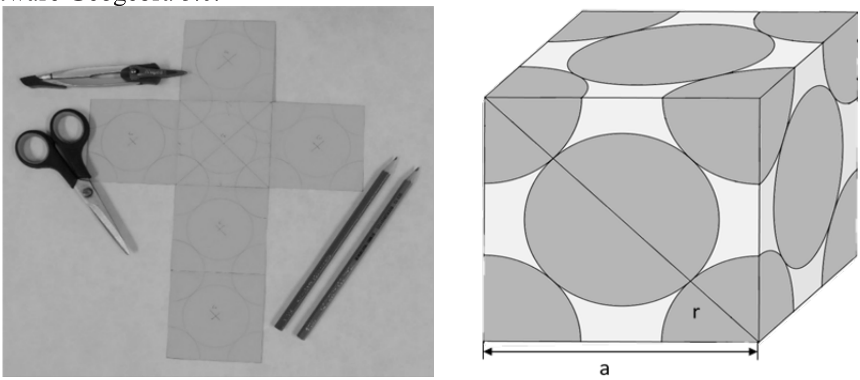

Figure 1. Different approaches to modelling chemical structure of face-centred crystal.

The tasks can be introduced to students in few different ways. The first option is to assign students to determine the density of a material with known crystal structure and to verify this knowledge with an experiment. The second option is more suitable for inquiry approach. The teacher can present students with a solid with cubic crystal structure and they must determine which one it is (primitive, body- or face-centred). The task uses the same principles but begins where the first has ended. The students should perform an experiment to determine the density of a material and then compare these results with the theoretical knowledge gained by geometry calculations.

Another of the geometry tasks could be helpful for determination of structure of organic and inorganic molecules. As the most representative example we can choose the molecule of methane. The carbon atom has sp^3 hybridization which means that the hydrogen atoms form the vertexes of a tetrahedron. Figure 2 shows the molecule of methane in cavalier projection. In Figure 3 two sections of a molecule of methane are displayed. These sections are necessary for calculating the bond angle.

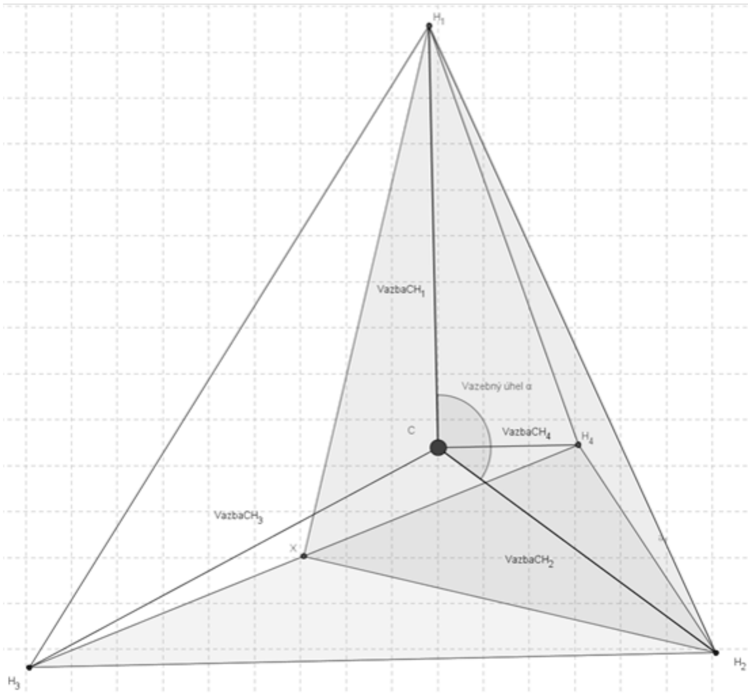

Figure 2. Molecule of methane in cavalier projection (Geogebra 5.0)

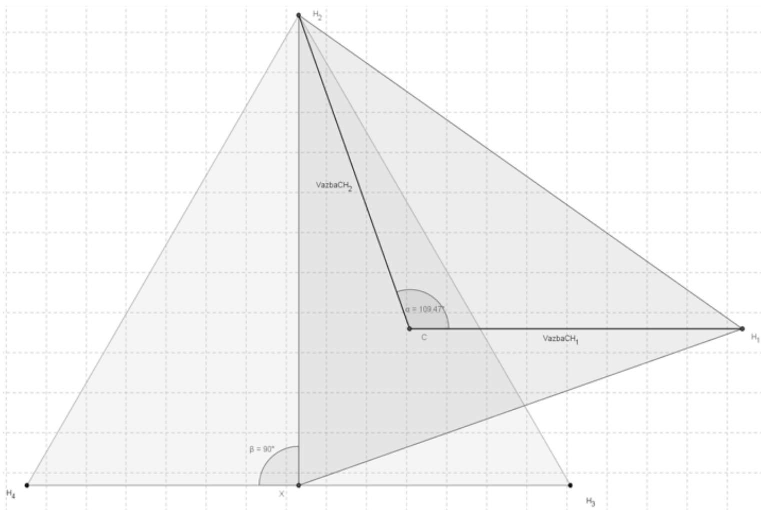

Figure 3. Two sections of methane molecule necessary for calculating the bond angle (colours correspond to Figure 2)

Mathematical functions are used in chemistry to describe many phenomena. To determine the mathematical function it is necessary to use functional analysis. On the contrary students can comprehend many concepts of theoretical functional analysis and their usefulness in other branches of science.

As an example we chose the analysis of functional dependence of reaction rate constant on temperature (Figure 4). This dependence leads the students to understanding the importance of exponential functions and their application in science.

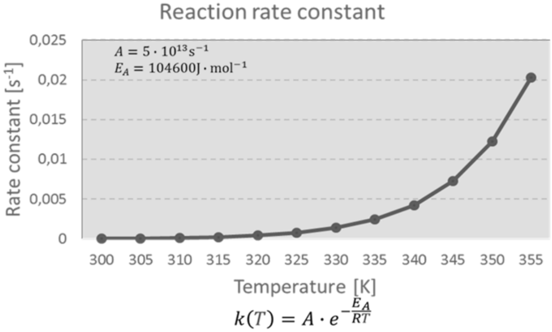

Figure 4. Graph of a functional dependence of reaction rate constant on temperature

Analysis of dependence of concentration of reagents on time (Zusková, 2012) (Figure 5) can lead the students to monotonicity of functions. The students can plot the measured or calculated values of concentration or rates of reaction and come to a conclusion whether the function is increasing or decreasing.

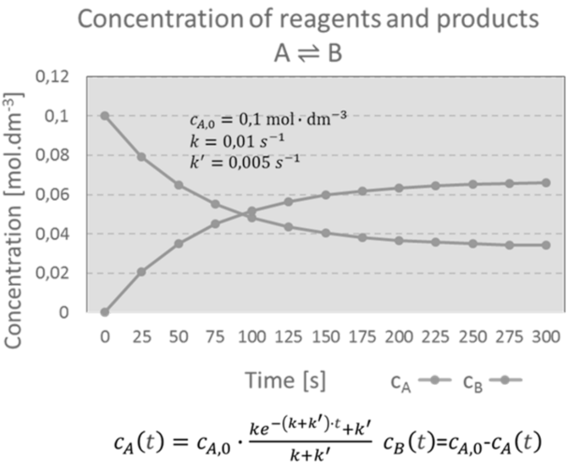

Figure 5. Graph of functional dependence of concentration on time in reversible reaction

Both these functional dependences are using exponential function. This type of function is according to our research the most problematic for high school students (Cífková, 2015).

Another way to demonstrate the usefulness of higher functional analysis to students is the modelling of atomic orbitals (Atkins, de Paula 2010) (Figure 6).

Figure 6. 3D-printed models of atomic orbitals (from left: p_x, $f_{x3-3xy2}$ and five d-orbitals).

Recently, colleagues from our department have been creating molecular models and teaching aids using 3D printing (Míka & Šmejkal, 2016). 3D printer makes it possible to create such spatial models of orbitals and chemical structures that are hardly conceivable by students.

The third area of mathematics that is connected to chemistry is calculations. It is an everyday task for a chemist to calculate the basic chemical quantities. As an example we can use determining the stoichiometry of a reaction. We offer several approaches to this problem. The basic one is to mark the stoichiometric coefficients with variables and then determine these variables by solving a system of linear equations. There are as many variables as the compounds in a chemical reaction and as many equations as the elements. In this state we can implement mathematical theory (or algebraic theory) about the number of solutions. This theory tells that the number of different solutions of a system of linear equations is determined by number of variables and number of linearly independent linear equations (Bečvář, 2005; Zusková, 2012). We have to add that the equations we get are homogenous (this means that the "right" side of an equation is zero). This means that if the number of elements equals to the number of compounds in a reaction only one "trivial" solutions is possible – all the variables have zero value. So the only system of linear equations that is suitable for our purpose is the one with more variables than equations, which means that it has an infinity of "non-trivial" solutions. The task to determine which the right solution is needs the application of chemical principle. We have to choose the solutions that has only whole numbers and is the lowest.

Another way of solving this problem is using oxidation a reduction partial reactions (Housecroft, Sharpe, 2014). This principle can only be used in reactions that are connected to electron exchange and the change of oxidation state. As an example we can use simple reaction of hydrochloric acid and potassium permanganate shown in Figure 7.

$$
\begin{array}{llr}
HCl + KMnO_4 & \dashrightarrow \; Cl_2 + KCl + MnCl_2 + H_2O & \\
\text{oxidation:} & 2\ Cl^{-I} - 2e^- \rightarrow 1Cl_2^0 & /\cdot 5 \\
\text{reduction:} & 1Mn^{VII} + 5e^- \rightarrow 1Mn^{II} & /\cdot 2
\end{array}
$$

Figure 7. Chemical equation of reduction-oxidation reaction.

The first step of Gaussian method of solving a system of linear equations has to be applied. This first step requires finding the least common multiple of number of electrons being exchanged.

Another example could be simple expressing the unknown quantity from a formula. When students first meet this problem in mathematics (13 to 15 year-old students) the mathematical phenomenon of unknown is very abstract for them. Teachers of mathematics mostly use geometry formulas that are still a part of mathematics. Chemistry could help them to see the importance of this skill by showing the application. An example can be seen in Figure 8.

Calculation of the mass of a solute:

$$w_i = \frac{m_i}{m_{tot}} \qquad m_i = w_i \cdot m_{tot} \qquad m_{tot} = \frac{m_i}{w_i}$$

Figure 8. Expressing the unknown from a formula
(Meaning of symbols: w_i – mass fraction of solute, m_i – mass of solute, m_{tot} – total solution mass)

The fourth part of mathematics that is strongly connected to chemistry is mathematical statics and graphs. Chemistry is using graphs and charts as any other natural science or even humanity science. The theory of probability and mathematical statistics is very useful in modelling some of the phenomena in chemistry. Graph plotting and chart-making are important skills that should be acquired by students. This means both data interpretation and creation of these statistical tools. Gained results are in accordance with the research of the team of professor Cídlová (2015).

An example could be modelling of radionuclide fission (Zeldovich & Yaglom, 1987) and plotting the results in a graph. From the results plotted in a graph the students can find out that the dependence is exponential, and that the nuclear fission is first-rate reaction (see Figure 8).

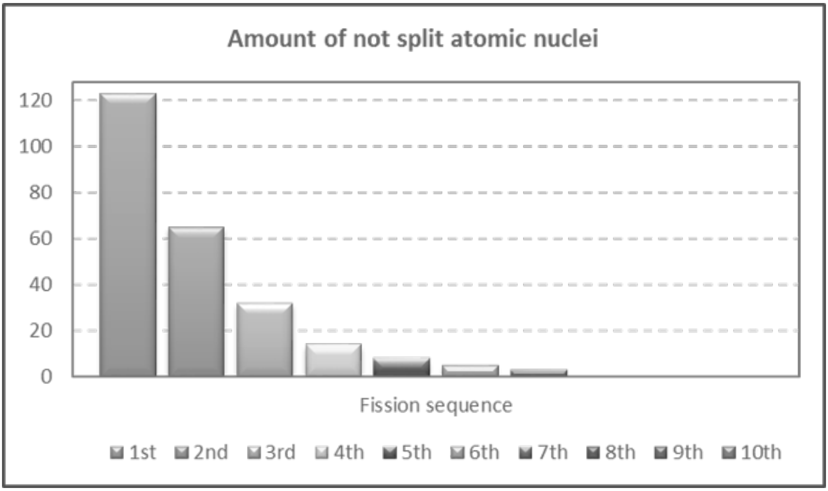

Figure 9. Graph of the results of an experiment simulating nuclear fission

We can take some amount of coins that will represent nuclei of a radionuclide. The students toss the coins and make record of the results of their experiment. The coin-toss determines whether in the first half-life the nucleus disintegrated or not (e. g. if the result is heads the nucleus has disintegrated and if the result is tails it did not). The student makes note of number of preserved nuclei. Then he takes the coins with tails result and tosses again simulating the second half-life. He does this till all the nuclei disintegrate.

Conclusions and implications

The paper presents solutions to the problems of connecting the interdisciplinary topics of mathematics and chemistry in a form of tasks created for the students of grammar schools. Practical verification of the selected tasks with grammar school students has been conducted while teaching mathematics, chemistry and physics. This type of tasks could help to construct complex problem solving skills necessary for further education. Complex scientific thinking belongs to key components of scientific literacy nowadays. Described examples can be used in many different ways to improve both science and mathematical literacy of students.

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The use of virtual chemical laboratory in the education of students with impaired hearing and speech

The basis of chemical education is experiments. This assumption is true on all levels of the chemical education. Chemical education gives positive, tangible results especially when the learner personally performs chemical experiments. Transforming matter and examining its various properties they engage their senses, and in this various receptors to solve created problems. This commitment is a factor for better memorizing knowledge and understanding chemistry in terms of the structure of matter and chemical transformations (Skrzypczak, 1978).

Work of learners is the more effective, the more clearly defined are the goals that they have to achieve a result of intellectual and practical actions. This is consistent with the taxonomy of learning objectives B. Bloom, which on Polish soil corresponds to taxonomy of learning objectives B. German and K. Czupiałowej, adapted for chemical education (Bloom et al., 1956; Czupiał & Niemierko, 1977; Andreson & Krathwohl, 2001). The taxonomy distinguishes two levels, this is the level of knowledge and skill level. In the first level, there are two categories:

A – and memorizing knowledge also B - understanding knowledge by learners. In the second level, distinguished by category C - application of knowledge in a typical situation, and D - the use of knowledge in a new situation, and so in problem solving. In category A there are five sub-categories, and these are knowledge of: terminology, concepts, facts, laws, policies, rules and classification systems. In the B category are subcategories as: checking understanding of the issues, checking correctness of the interpretation, checking conclusions and prediction of events development. In the next category C with a much higher educational value than the previous are marked skills: the observation of phenomena and perception of symptoms of chemical reactions, making the description of observations, measurements, selecting the right equipment for the measurement and execution of the experiment, a summary of the results and estimation accuracy, performing calculations according to known methods. In the category D with the highest educational value into considerations are taken: ability to ask questions, to formulate working hypotheses and conclusions, as well as the design of appropriate procedures for carrying out the experiment (Czupiał, 1977). In the case of achieving the objectives of each taxonomic categories with the help come virtual chemical laboratories. Unfortunately, designed and constructed so far virtual chemical laboratories are based on interfaces such as mouse and keyboard. So they do not give good opportunities to simulate laboratory work because work is based only on appropriate moving the mouse cursor over the surface of the monitor screen (Bílek, 2010).

Embodied cognition theories in chemistry teaching

In recent years, increased interest in models of representation called “embodied cognition theories.” According to these models human knowledge requires a “re-experience” of given event using sensory processes that participated in the original perception of the stimulus Barsalou 1999; Wilson 2002; Prinz 2002). It turns out that the mental processing of the student information in the multimedia instructional materials supported by movement causes activation of these brain areas that are responsible for cognitive processes. The inclusion of human movements to this process makes learning with the use of multimedia content become more effective (Ayres et al., 2009; Wong et al. 2009). The confirmation of these conclusions are results supported by conducted magnetic resonance imaging, which showed that the cerebral cortex is activated when the transmission of information is supported by appropriate gestures (Macedonia, Müller & Friderici, 2010).

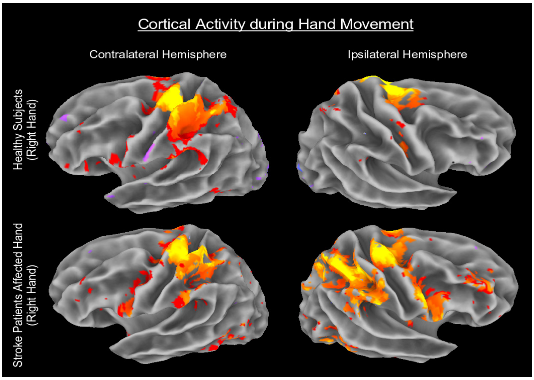

Figure 1. Cortical activity during hand movement. Picture from http://www.martinos.org/neurorecovery/technology.htm

In support of this assertion Johnson et al. (2011) have identified computer gesture recognition as an indispensable technology that will have a big impact on education in the near future. In already known from literature research for educational use of motion sensors detecting movement increased the effectiveness of education. Described literature reports have encouraged us to develop a virtual chemical laboratory in which the work is based on movement and gestures of the user, recorded by the Kinect sensor (Kinect, n.d.). The use of natural user interfaces (NUI)) (Murphy, 2012) creates new possibilities in the design of virtual laboratories based on gesture-based system.

Problem of research

Taking into account the embodied cognition theories was prepared virtual laboratory, which uses a system of recognition of gestures and movements. Academic experiment was designed to explore how the use of gesture based system in a virtual chemistry laboratory, affects the effectiveness of chemical education in the various categories of taxonomy of learning objectives, it is - in terms of memorizing information, understanding it, use of knowledge in a typical situation and while problem solving laboratory.

By using the sensor Kinect simulation such as grasping in hands laboratory equipment and laboratory glassware and appropriate mounting them can be done. Possible is, inter alia, simulation of receiving a solid-liquid pouring solutions to laboratory vessels.

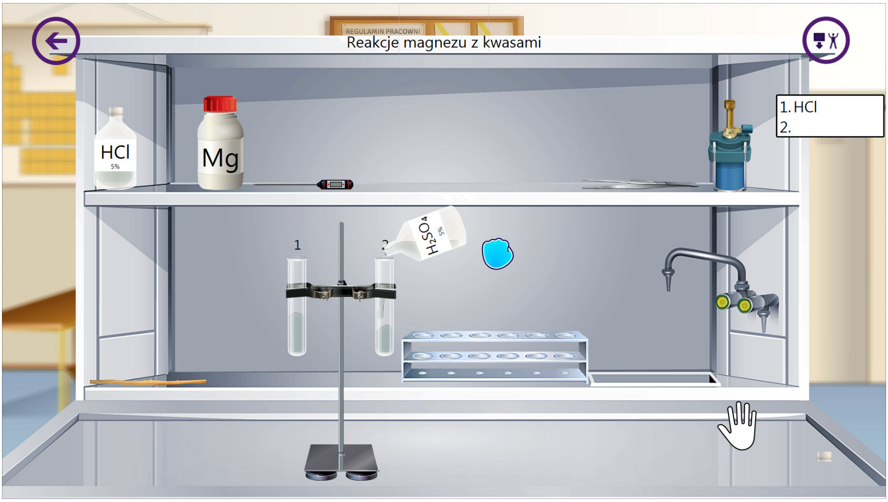

Figure 2. Virtual Laboratory - simulation of pouring solutions and liquids

In the program was used simulation of the liquid movements during transfusion or during the chemical reaction and the simulation of the movement of particles of solids during their collection and pouring into the blood lab. The program allows you to perform some chemical experiments within the scope of chemistry curriculum for high school and secondary school. In the virtual chemical laboratory can be performed, inter alia, the following experiments: The burning of carbon, sulfur, oxygen and magnesium; Comparing the chemical reactivity of metal; Preparation of hydrogen in the reaction of zinc with hydrochloric acid; Preparation of the salt by treatment with an acid to hydroxide; Chemical reactions magnesium salts; The precipitation of sparingly soluble salts precipitate; Analysis of behavior of aluminum oxide to the base and acid; Test reactions of aqueous salt solutions; Effect of temperature on the rate-determining chemical reaction;

Effect of substrate concentration on the rate-determining chemical reaction; Preparation oxygen from manganate(VII) potassium; Preparation of carbon oxide(IV); Characterization of carbon monoxide(IV); Law of mass conservation; Preparation of acid; The chemical reaction of magnesium oxide and copper oxide(II) with a solution of hydrochloric acid; The reaction of copper nitrate(V) of silver(I); Examination of the impact of temperature on the solubility of gases in water; Decomposition of hydrogen peroxide; Effect of alkali and acid oxides; The chemical reaction of phosphorus oxide(V) with water; Reaction of the magnesium chloride, iron(III); Tollens test; Trommer test; Preparation of sodium hydroxide by reaction of sodium with water. In the program was applied system to monitor accuracy of the performance of specific laboratory activities, so that inappropriate steps are signaled to user and blocked. The aim is to familiarize the user with rules of proper and safe operation in laboratory.

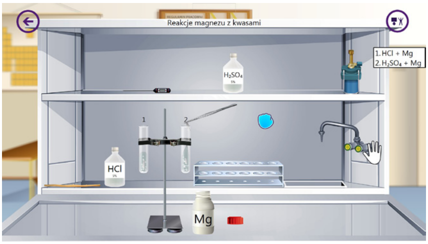

Figure 3. Conducting the reaction of magnesium with acids in a virtual lab

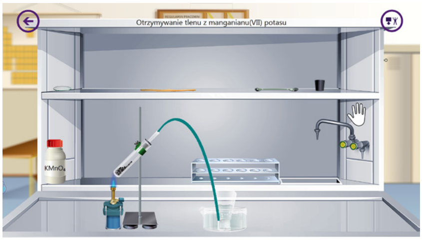

Figure 4. Preparation of oxygen manganate(VII) potassium in a virtual laboratory

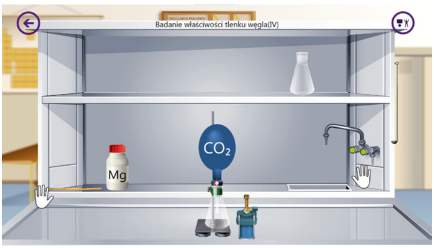

Figure 5. Characterization of carbon oxide(IV) in a virtual laboratory

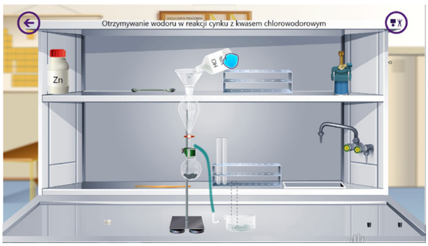

Figure 6. Preparation of hydrogen in the reaction of zinc with hydrochloric acid in a virtual laboratory

Conducted research on the effectiveness of educational chemical virtual laboratory in high school and in secondary school. Reviewed results show a significant impact of virtual laboratory on improvement of chemical education quality (Jagodziński & Wolski, 2015).

Summary of research results:

The use of virtual chemical laboratory based on a system of gestures (GBS) in middle school among students resulted in an increase of information understanding. This increase was due to the performance of gestures and movements by students while performing experiments in a virtual lab. For middle school students working with a virtual lab better results in terms of understanding information (B) have further consequences in the form of better performance by them in terms of solving problems (C) requiring a good understanding information and creative thinking (D). Working with virtual laboratory has positive effect on the durability of knowledge for middle school students, because the manual activities that students perform alone while working in it, for them to greater attention and perception. It affects the greater degree of absorbing and understanding information (A, B) with positive results in problem solving (C, D).

Here are the diagnostic survey questions, on which answered the goups of surveyed students in middle school and high school:

1. Has work in a virtual lab increased your commitment to the work in a real lab?
2. Do you prefer to work in a real lab after practice of performing experiments in a virtual laboratory?
3. Has work in a virtual lab helped to increase the efficiency of your work in a real lab by shortening the time required to perform experiments?
4. Has work in a virtual lab helped to increase the efficiency of your work in a real lab by reducing the number of errors during the experiments?
5. Has work in a virtual lab then encouraged you to verify them in real lab?
6. Would you like to while working in a virtual lab perform more experiments than normally in a real lab than expected in schedule?
7. Has work in a virtual lab helped you so you can easily design new chemical experiments?
8. Has work in a virtual lab helped you to more confident perform laboratory activities in the real lab?
9. Has work in a virtual laboratory strengthened you in the belief that you can perform experiments with positive results in a real lab?
10. Has work in a virtual lab increased your believe in the efficiency increase of work related to the performance of manual tasks in the laboratory real?

The survey results confirm the usefulness of virtual chemical laboratory using a system of gestures and movements in chemical education. Examined study groups working with the virtual lab confirmed that it increased their commitment to work in a real lab. In majority of surveyed students increased their willingness to work in a school chemistry lab, as well as increased their interest in the subject of chemistry. Students also felt that increased their efficiency, because they were able to perform experiments in less time committing fewer errors. Positive experimental results obtained by pupils when working in a virtual lab encourage students to repeat them in a real laboratory. By working with a virtual lab has increased students' problem-solving skills in laboratory which confirmed the results obtained by them in the activities corresponding to D category taxonomy of learning objectives. The survey results also indicate that students have mastered better laboratory activities thus increased their belief that they will now perform more experiments with positive results. Students emphasized that training in a virtual laboratory increased their sense of the effectiveness of their work in a real lab (Jagodziński & Wolski, 2014).

Summary

Analyzing the obtained results it can be stated that the use of virtual chemical laboratory based on a system of gestures and movements gives good results in the chemical education. The test results gave a positive answer to the research questions. Students working with a virtual lab had a better performance in terms of memorizing knowledge, and also showed greater knowledge durability than students who have not worked with this means of teaching. Also, these students are able to better understand the context of relayed information. Rose among them the ability to use what has been learned in solving tasks in situations known to them from lessons. Thanks to that even better results were achieved in solving the problematic laboratory tasks, and this is related to achieving targets contained in category taxonomy objectives of highest educational value. Comparing achievement of students in particular groups of middle school and high school can be stated that the use of gestures and movements in a virtual chemistry laboratory provides higher educational efficiency than for students who do not work with a virtual lab. The use of the sensor Kinect recognizing gestures and movements can increase interactivity and educational effectiveness of virtual laboratory. This confirms Ayres et al. (2009) and Wong et al. (2009) about the fact that incorporating human movements to the cognitive process of learning supported by multimedia content using gestures gives better results and is more effective. As observed by Macedonia, Müller & Friderici (2010) this is connected with the activation of certain areas of the brain through gestures and movement. Indeed, in our study group of students working with a virtual laboratory, using gestures and hand movements to control it they achieved the best results in education. Students of other groups looking on teachers demonstrations and instructions on film that did not use these gestures achieved worse results especially in solving chemical problems. The results of studies on the application of the system to recognize gestures and movements in a virtual chemistry laboratory actually confirmed the prediction of Johnson et al. (2011), the computer gesture recognition technology will have a major impact on education in the future. Developed by us virtual laboratory with the sensor Kinect, in our opinion, is the new path to virtualization different laboratories making a very similar manual operation in a virtual environment to the real environment.

Virtual chemical laboratory in the education of students with impaired hearing and speech

Achieved results of research on the use of virtual laboratory chemical encouraged us to use this means of teaching in chemical education of students with impaired hearing and speech (Jagodziński & Wolski, 2012).

We are interested in the problem, whether it is possible to implement a virtual laboratory in process of chemical education of students with impaired hearing and speech. An interesting aspect could be a problem of these students to use gestures and movements in working with a virtual lab, bearing in mind the fact that these students already operate with gestures when using sign language characters. Are they therefore better suited to work in the virtual environment? Or maybe it will not affect the effectiveness of their work in this lab? We are also curious to what extent this didactic measure will affect the educational achievements of students in the subject of chemistry, compared to the results that have achieved, students without these dysfunctions.

Cognitive abilities of students with impaired speech and hearing

In order to understand how difficult the problem of teaching the subject that is experimental chemistry and attempts to increase the efficiency of chemical education of students with impaired speech and hearing take a look at the key issues related to cognitive and mental abilities of the students. In the natural sciences, including chemistry, information about the surrounding reality, the structure and properties of matter are obtained in different ways. However, the most important information methods include contact of students with the outside world. This contact with the environment is provided by a properly functioning receptors. From them gathering information starts. When one of the senses is damaged it interrupts the connection with reality. This results in a lack of information flow. This applies particularly to people with hearing impaired. Deaf people do not know anything about the sounds, rhythms, and above all do not hear the speech and its entire intellectual and emotional wealth. The cognitive ability of human allow not only the collection and processing of information but also to adapt to the environment and to the impact of this environment which is very important for learning chemistry.

Therefore, the development of cognitive abilities of students who are deaf or hard of hearing is clearly limited. This restriction, however, motivates these students to the effort to develop mechanisms to activate the cognitive, intellectual and adaptive abilities. According to many scientists students called deaf are deprived of the opportunity to receive sound stimuli by the sense of hearing. According to them, all the deaf can not hear, but some of them can speak. While deaf-and-dumb are those students who since birth or as a result of early hearing loss have not learned the language through natural human contact or through education (Jenny, 1990). Considering the visual perception of deaf students it should be stressed that the process of acquiring cognitive experience is different than hearing students. Understanding the reality in case of deaf students is based primarily on visual impressions. But it also involves smell, touch, taste, vibration.

Important in chemistry teaching of deaf students is the issue of memory. It does not develop and does not work with the auditory memory. Due to the dominance of visual perception in cognitive activities, including perceptions and memory outweigh visual images. In the past there was the view that in the case of visual memory of deaf and hard of hearing students their different cognitive situation of considerable visual content preferences, will achieve better results in terms of screen memory than hearing people. Numerous studies conducted in the US and Europe have not confirmed this view (Lang & Propp, 1982) Research on verbal memory, called semantic of deaf and hard of hearing is divided depending on the memorized material: memorizing words and signs mimic-sign language, memorizing sentences and memorizing texts. Studies have shown that deaf students better remember sign marking snap than words. Deaf students better combine logical groups of gestures than words. In the process of learning deaf student must always be followed by the transfer of short-term memory (fresh) to long-term memory. This requires a short break, during which information are take into and kept in mind. Even after a few interesting activities students will not remember as the information follow in too quick succession. Of great importance in the process of memorizing new material being presented is a suitable combination of it with the facts already known. Visual pairing should be a base for deaf students' for learning and memory exercises both images, situations and language. Events presented in the form of image-film sequences, are remembered better than shown only in the form of written or oral (Myklebust & Brüder 1953; Lang et al., 1998).

Research Focus

Preparing virtual chemistry lab to work with students deaf-and-dumb and hard of hearing, we formulated the following research questions:

Does the use of gesture recognition system in a virtual laboratory will help to increase the efficiency of chemical education of students with impaired hearing and speech?

Will the assumptions of embodied cognition theories be confirmed in the chemical education of students with impaired hearing and speech, in the implementation of experiments in a virtual laboratory?

Whether through the use of virtual laboratory system supported by GBS increase the emotional involvement of students with impaired hearing and speech, and increase sense of self-efficacy in laboratory work?

The course of study

The first phase of the research involves video recording the image of a sign language interpreter describing the course of chemical experiments.

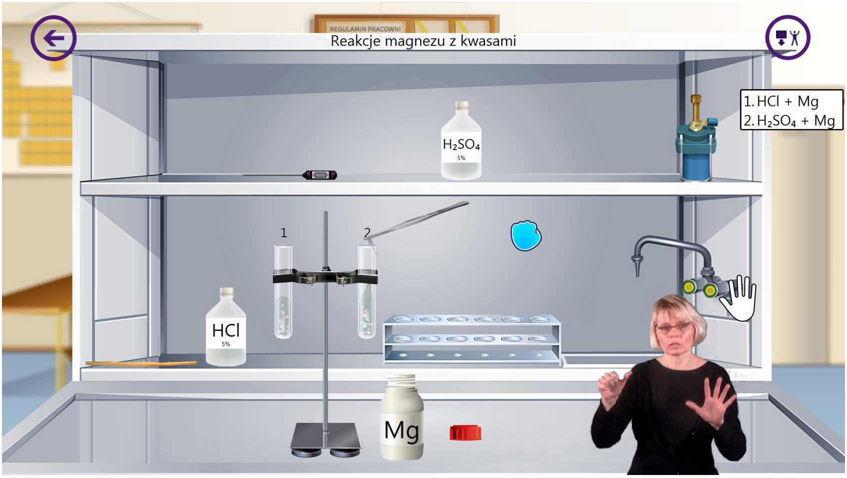

Figure 7. Image of virtual chemical laboratory with the image of a sign language interpreter transmitting commands to perform the experiment

The second stage of the study is the determination of experimental and control groups of students with impaired hearing and speech with the principles of randomization.

The third step is to conduct educational experiment that is research using virtual chemical laboratory in the experimental group and the control group, in which virtual chemical laboratory is devoid of the image of a sign language interpreter, and replaced with conventional instructions at the bottom of the screen. The next stage of the research is to answer the diagnostic survey questions.

The final step is the determination of the level of educational effectiveness of chemical virtual laboratory in the education of students with impaired hearing and speech.

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Analysis of scoring schemes in Physics Olympiad for more correct scoring in assessment

Introduction

Importance of assessment in education can be shown from its role in giving opportunity to manage the instruction in a more effective way (formative assessment) as well as in assessing the level of acquired knowledge (summative assessment) to give an essential feedback either to the teacher or to those who are taught. One of the most often used ways to do summative assessment in physics is assessing solutions of physical problems and tasks. This is also used to distinguish between the performance of participants taking part in various physical competitions such as a worldwide competition – Physics Olympiad (PhO). Here PhO participants gain points for their correct solutions of physical problems created according to the national curriculum with a higher level of difficulty compared to physical tasks normally solved during the instruction.

Scoring scheme proposed by the author of a physical problem is used as the guide to score individual PhO participants. Therefore, it can be considered as the most important factor which determines the overall order of PhO participants done according to the sum of all gained points. As the physical problem which should be solved demands various skills and knowledge it is divided into a certain number j of partial subtasks which could be scored independently. Author of physical problem determines maximum possibly gained points X_i^j which should i-PhO participants get for the correct solution of j-subtask. We define the score $\hat{X}^j$ as random variable, where X_i^j is the result of the i-th measurement, the score of the i-the PhO participants on the j-th subtask. These subtasks are usually expressed by questions in the text of physical problem, often denoted as a), b), c), … . However, finer division of scores can be also presented in the author´s solution.

Sometimes the same knowledge or skills are needed to correctly solve more than one of j-subtasks and therefore PhO participants can be awarded or punished for the same thing more than once. However, if random variables $\hat{X}^j$ are chosen correctly, we can consider them to be independent random variables.

Our aim is to prove that the case when random variables $\hat{X}^j$ are not independent is common in the PhO problems and determine the suitable procedure to modify the original scoring scheme in order to get new independent random variables $\hat{\xi}^k$. This is followed by the analysis of influence it has on the results of PhO participants.

Methods

Sample used for our analysis consisted of the solutions of N = 49 PhO participants who took part in PhO in the school year 2015/2016 in the Nitra district in Slovakia. Solutions of 4 physical problems were scored by experienced assessors according to the scoring scheme. Therefore, it could be considered objective at a certain level as well as suitable for the (partial) analysis of the original scoring scheme proposed by the authors of physical problems.

In the research of various scientific disciplines, we are almost always interested in the relationship between certain variables. As it was mentioned above, we focused on the analysis of independency of random variables $\hat{X}^{j}$ standing for the scores of PhO participants for solving j-subtasks of a certain physical problem. “Whenever two random variables have a nonzero correlation coefficient they are dependent.” (Spiegel, 1998, p. 268). For this purpose, we have chosen one of the most widely used statistical tool – Pearson′s correlation coefficient, denoted r or ρ. It is a statistical measure of the strength of a linear correlation with the values ranging from -1 to 1. Its values can be computed from various equivalent formulas which are presented for example by Spiegel (1998), Markechová, Stehlíková, Tirpáková (2011). Modified formula used for our case of two random variables $\hat{X}^{j_1}$ and $\hat{X}^{j_2}$ is

$$\rho^{j_1,j_2} \equiv \rho\left(\hat{X}^{j_1},\hat{X}^{j_2}\right) = \frac{\sum_{i=1}^{N} X_i^{j_1} X_i^{j_2}}{\sqrt{\sum_{i=1}^{N}\left(X_i^{j_1}\right)^2}\sqrt{\sum_{i=1}^{N}\left(X_i^{j_2}\right)^2}}$$

(1).

The linear correlation coefficient ρ^{j_1,j_2} may be positive or negative. Positive values denote positive linear correlation $X_i^{j_2}$ tends to increase with $X_i^{j_1}$, negative values denote negative linear correlation $X_i^{j_2}$ tends to decrease with $X_i^{j_1}$. A value of 0 denotes no linear correlation altho $X_i^{j_1}$ there may in fact be a large nonlinear correlation (Spiegel, 1998). The closer the value is to 1 or –1, the stronger the linear correlation. We can verbally describe the strength of the correlation using the guide that Evans (1996) suggests for the absolute value of ρ: *0,00-0,19 “very weak”; 0,20-0,39 “weak”; 0,40-0,59 “moderate”; 0,60 – 0,79 “strong”; 0,80 – 1,0 “very strong”* (Pearson′s correlation, n. d.). We are particularly interested in at least strong or very strong linear correlations as they give evidence that $\hat{X}^{j}$ are not independent random variables in general. Therefore, the correlation matrix ρ with matrix elements ρ^{j_1,j_2} has been calculated in the case of every physical problem. We calculated, for further modification of the original scoring scheme, correlation matrix R with matrix elements R^{j_1,j_2} as follows

$$R^{j_1,j_2} = N\sum_{i=1}^{N} X_i^{j_1} X_i^{j_2} - \sum_{i=1}^{N} X_i^{j_1} \sum_{i=1}^{N} X_i^{j_2} \quad (2)$$

(2).

The second method modifies the original scores getting independent random variables $\hat{\xi}^k$. We studied the case where the number n_X of random variables $\hat{X}^j$ in the original scoring and the number n_ξ in the transformed scoring $\hat{\xi}^k$ were equal ($n_x = n_\xi = n$). To get independent random variables either correlation matrix ρ (formula (1)) or correlation matrix R (formula (2)) was needed to be diagonalised. It is easy to see, that if an element of the matrix R^{j_1,j_2} is zero, the corresponding element of the matrix ρ^{j_1,j_2} is zero too. The diagonal elements are different in general. Matrix R is hermitian, therefore R is diagonalizable. In other words, there exists a unique linear transformation (unique up to equivalence) giving new random variables $\hat{\xi}^k$ which are independent random variables. To diagonalize matrix R we can use standard decomposition tools (Wolfram Mathematica Online or other online eigenvectors and eigenvalues calculators). Random variables $\hat{\xi}^k$ are in the first step defined as the linear combinations of the original variables $\hat{X}^j$.

$$\hat{\xi}^k = \sum_j a_{kj} \hat{X}^j \tag{3a}$$

(3a),

where a_{kj} stands for coordinates of eigenvectors of diagonalised correlation matrix and for the i-th measurement we obtain the transformation (the modified score of the i-th participants for independent k-th task)

$$\xi_i^k = \sum_j a_{kj} X_i^j$$

(3b).

The new, modified task represented by the new random variable $\hat{\xi}^k$ is defined by statistical tools only – its content is not defined in general. This should be a subject of further research.

To compare the results (the scores before and after the transformation), we introduce new random variables $\hat{\xi}^k$ as follows

$$\hat{\zeta}^k = \frac{10}{S(\xi)} \hat{\xi}^k$$

(4a),

and for the particular scores

$$\zeta_i^k = \frac{10}{S(\xi)} \xi_i^k$$

(4b),

$$S(\xi) = \sum_{k,j} a_{kj} X_{\max}^j$$

(5),

where $X_{\max}^j$ is the maximal score for the part j of the problem. In our case $\sum_j X_{\max}^j = 10$ is the maximal score for the problem before the modification and 10/S(ξ) is a scaling factor. Example of scores of i-PhO participant solving physical problem I is in Table 1.

Equation (4) changes only the scaling of the independent random variables $\hat{\xi}^k$. Now, if a participant has no solution of the problem (his/her score is 0 for the problem), its modified score is 0 too. Also, if he solved the problem correctly and his/her score is 10, his/her modified score is 10 too. We note here, that the scaling has no influence on the independency of random variables $\hat{\zeta}$.

Table 1. Example of full modification of scores gained by a particular PhO participant

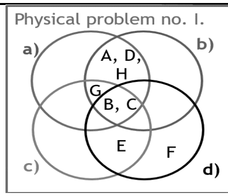
j/k	**a/1**	**b/2**	**c/3**	**d/4**	$\sum$	**Final scores for PhO participant**
Original scoring scheme	2	2	3	3	10	
X_i^j	2	0	2	0	4	X_i = **4**
ξ_i^k	2,143	0,792	-0,505	1,590	4,019	ζ_i = **5,55**

Qualitative analysis of the text of physical problem I (Table 2) was done to find out the relationship between the strength of correlation and the content of the j-subtasks. Firstly, we identified 8 categories A – H of skills and knowledge needed to correctly solve j-subtasks of physical problem I - Harmony of the seas (Iuventa, 2015). Definitions in textbooks, approaches of PhO participants (their expressions) as well as demanded knowledge and skills were taken into account. For better understanding we give examples of few categories: A – weight of the displaced liquid is equal to the weight of the ship, B – forces F_g and F_{vz} acting on the floating ship are balanced, C – direction and point of action of forces F_g and F_{vz},…, E – where is situated the centre of mass when the ship is tilted and when it is not, F – condition of equilibrium when forces have turning effect on the ship…

Secondly, we considered for each of j-subtask the need of A-H categories to solve it. When it was identified, the mark ☑ was put in Table 2 for a particular j-subtask. Finally, the results were expressed graphically using sets and elements of sets. We define particular subtasks a), b), c) d) as sets a,b,c,d, and introduce set variables j ($j \in \{a,b,c,d\}$). Now, A-H are their elements. The number of elements in the intersection of j_1 j_2 sets was counted and compared to calculated correlation coefficient ρ^{j_1,j_2}. Subsequently, strength of correlation was characterised according to its values (Table 2). As the selection of categories A-H was done only by author of this article this method can be considered to be subjective but important for the later analysis and interpretation of our results.

Table 2. Qualitative analysis of the text of physical problem I

j	A	B	C	D	E	F	G	H
a)	☑	☑	☑	☑			☑	☑
b)	☑	☑	☑	☑			☑	☑
c)		☑	☑		☑		☑	
d)		☑	☑		☑	☑		



intersections j_1j_2	ab	bc	ac	cd	ad	bd
number of elements	6	3	3	3	2	2
strength of correlation	strong	moderate			weak	

The influence of modification on the ranking

We focus here on the analysis of the effect that modified scores had on the results of PhO participants. First monitored parameter was the difference in the number of gained **points** (scores) denoted ΔP_i for a certain physical problem before and after modification of the scores. As it is calculated

$\Delta P_i = \xi i - X_i$ *(modified – original points)* (5),

its positive values indicate improvement in scores.

The second monitored parameter was difference in the **order** of participants ΔO_i calculated as

$\Delta O_i = O_i^M - O_i$ *(modified – original order)* (6),

where negative values mean improvement. To study the order of the PhO participants all of them were ordered according to the original scores and then according to a modified scores. When there were PhO participants whose scores for solving particular physical problem were the same, the order of all of them was the same, too. The order of the next participant was determined as it was counted from the first of the previous group. For example, 6 participants had the same scores and all finished on the 14th place. The order of next participant was therefore the 20th place. For our analysis we characterised that by "nonzero changes" we understand difference ΔO_i with the value at least ±1 place and by "significant changes" (in order of PhO participant after modification) difference ΔO_i with the value at least ±5 places . Minimum and maximum values of positive and negative values of ΔP_i and ΔO_i were also studied and it was analysed for which cases it was typical.

Results

Pearson´s correlation coefficient was used to investigate the independency of random variables $\hat{X}^j$. We found out that the values of linear correlation coefficient vary from -0,382 to 1,000 and in many cases they are nonzero. Even 37 % (22 out of 60) of all considered correlations can be described as strong or very strong linear correlations. This means that random variables $\hat{X}^j$ are not independent as there is linear correlation between them.

Possible approach presented in Table 2 shows that in the case of physical problem I there is a positive relationship between the value of correlation coefficient ρ^(j_1,j_2) and the number of elements A-H in the intersections of sets j_1 and j_2 (A-H representing skills and knowledge needed to solve j_1 and j_2 subtasks). However, this approach can be characterised as subjective and further investigation for higher number of cases is vital to generalise these results.

Modification of scoring scheme effected the results of PhO participants. Differences between original and modified number of points range from -0,36 to 2,97. They resulted in a change of order ranging from -20 to +12. Sometimes maximum difference ΔP of scores corresponds to maximum difference in order ΔO, but not always and in other cases, despite the nonzero difference ΔP there is a zero change in the order. The example of results for physical problem III is presented in Table 3.

Table 3. Example of effect of modification on the results of PhO participants for physical problem II

O_i	1	2	3	3	3	3	3	8	8	8	8	8	8	14	14	14	14	14	14	20	20	22	22	22
O_i^M	1	2	3	4	4	4	4	9	16	9	16	4	16	19	25	13	19	19	11	23	12	25	31	13
ΔO_i	0	0	0	1	1	1	1	1	8	1	8	-4	8	5	11	-1	5	5	-3	3	-8	3	9	-9
ΔP_i	**0,0**	0,2	0,8	0,6	0,6	0,6	0,6	1,1	0,3	1,1	0,3	1,6	0,3	0,7	0,2	1,0	0,7	0,7	1,2	1,1	1,6	1,2	0,9	2,0

22	26	26	26	26	26	26	26	33	33	33	33	33	33	39	39	39	42	43	43	43	46	46	46	49
19	34	38	28	23	34	28	28	32	25	13	32	36	36	39	40	41	42	43	43	43	47	47	46	49
-3	8	**12**	2	-3	8	2	2	-1	-8	**-20**	-1	3	3	0	1	2	0	0	0	0	1	1	0	0
1,7	0,9	0,7	1,5	2,1	0,9	1,5	1,5	1,5	2,2	**3,0**	1,5	1,2	1,2	1,6	1,2	0,8	1,1	1,4	1,4	1,4	1,4	1,4	1,9	0,9

Order of PhO participants was changed in 78 of 196 considered cases (40 %). The majority (62 %) of all these nonzero changes affected PhO participants in the middle – from 20th to 39th place. Significant changes, described as changes in order in at least ±5 places, were also investigated. From all nonzero changes 40 % of them were significant and compared to all 196 studied changes (including zero changes too) there were 11 % of significant changes.

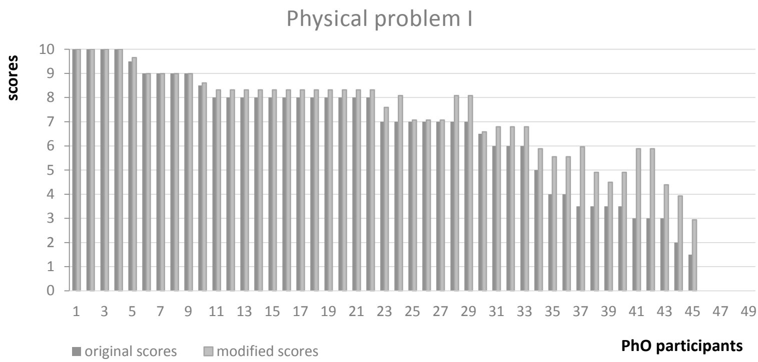


Figure 1. Comparison of original and modified scores of PhO participants for physical problem I

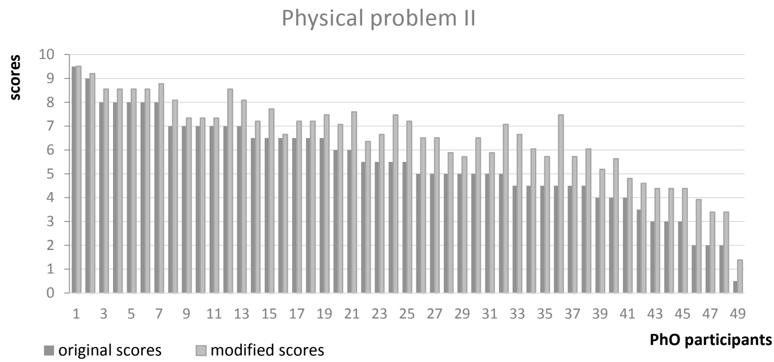


Figure 2. Comparison of original and modified scores of PhO participants for physical problem II

In the figures 1-5 are compared scores of 49 PhO participants before and after the modification of scores. When considering physical problems I-IV separately it can be seen than in majority of the cases the modified scores were higher than original ones. From the results presented in Table 3 it can be seen that for a particular physical problem III there were relatively big differences in order.

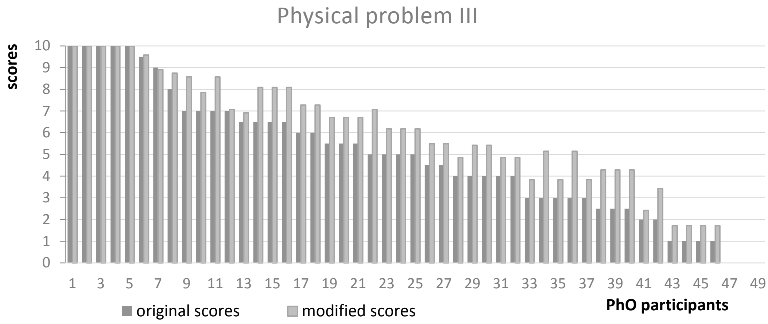


Figure 3. Comparison of original and modified scores of PhO participants for physical problem III

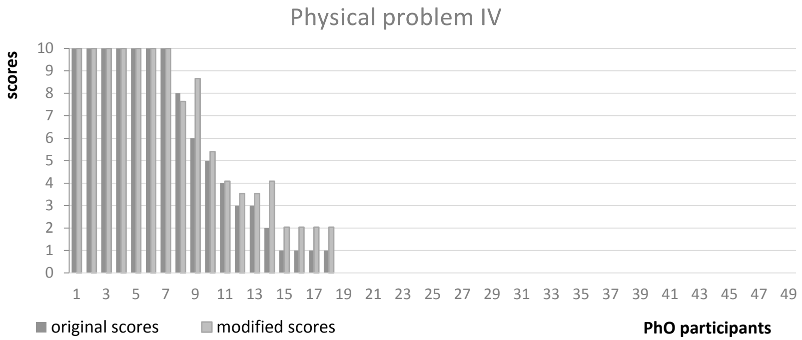


Figure 4. Comparison of original and modified scores of PhO participants for physical problem IV

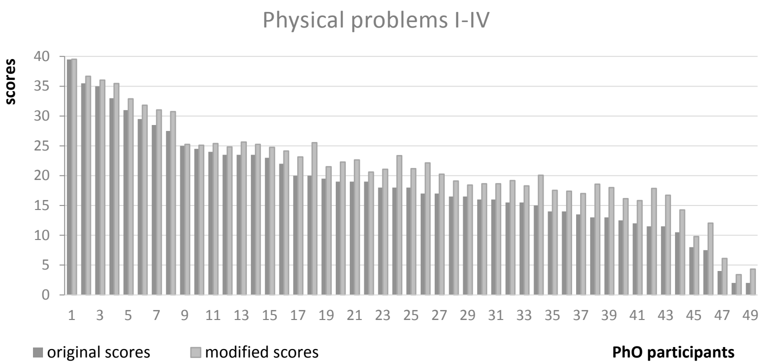


Figure 5. Comparison of original and modified scores of PhO participants for physical problems I- IV together

Table 4. Effect of modification on the final results of PhO participants who solved physical problems I-IV

O_i	1	2	3	4	5	6	7	8	9	10	11	12	12	12	15	16	17	17	19	20	20	20	23	23
O_i^M	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
ΔO_i	0	0	0	0	0	0	0	0	0	0	0	0	1	**2**	0	0	0	1	0	0	1	**2**	0	1
ΔP_i	**0,0**	1,2	1,0	2,4	1,9	2,3	2,5	3,3	0,3	0,6	1,4	1,3	2,1	1,7	1,7	2,1	3,1	5,5	2,0	3,3	3,6	1,6	3,1	5,4

23	26	26	28	28	30	30	32	32	34	35	35	37	38	38	40	41	42	42	44	45	46	47	48	48
25	26	27	28	29	30	31	32	32	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49
2	0	1	0	1	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0	0	0	0	1
3,2	5,1	3,2	2,6	1,9	2,6	2,7	3,7	2,8	5,1	3,5	3,4	3,5	5,6	5,0	3,6	3,8	**6,3**	5,2	3,8	1,8	4,6	2,1	1,4	2,3

In figure 5 and in Table 4 are compared scores of PhO participants as the sum of scores for physical problems I-IV. Although relatively big differences in order of PhO participants in analysis of particular physical problems were mostly compensated we could still say that in 14 cases the final order of PhO participant changed after the modification.

Conclusion and implications

We proved that random variables Xˆ^j scored according to the original scoring scheme proposed by the author of physical problem are not independent. Linear correlation between them was shown from nonzero values of Pearson´s correlation coefficient. In 37 % of all considered correlations strong or very strong correlations were identified according to the absolute value of correlation coefficient. For more correct scoring the modification of scoring scheme was needed and a unique procedure has been developed and applied in the case of PhO problems. The effect that this procedure had on the modified scores – independent random variables ξˆ^j – was analysed. The problem which remains is that negative scores for a particular physical problem can be obtained. In this situation even though a PhO participant is successful in solving few subtasks, he or she has worse results than the participant who gets 0 points (minimum possible scores). This will be the subject of further analysis.

The majority of modified scores gained for a particular physicals problem as well as the final scores increased after the modification. Modified scores resulted in the change of the order of PhO participants, mostly effecting places in the middle. These changes were not negligible.

General approach used in the proposed procedure of modification scoring scheme can be regarded as one of the strengths as this procedure can be applicable not only in the assessment of the results of PhO participants but also in other ways of assessment usually used in all types of schools during the physics instruction.

The matter of further analysis would be interpretation of new independent variables and its identification in the solutions.

Acknowledgements

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The inclined throw with air resistance

Introduction

Free fall is a type of motion in which the only force acting upon an object is gravity. Objects that are said to be undergoing free fall, are not encountering a significant force of air resistance. They are falling only under the influence of gravity. Under such conditions, all objects will fall with same rate of acceleration, regardless of their mass. A feather and stone will fall with equal velocity in a vacuum.

In presence of air, we have other conditions and therefore unequal velocities. It is easy to express these dependences with hyperbolic functions. However, in secondary and high schools these functions are unknown, very hard for use and to understand them. We found out other tools to solve this task. To avoid complex mathematical functions, we have been solving it with numerical methods.

Velocity of a falling object with air resistance is changing, and therefore air resistance force (ARF) (drag) is changing too. ARF versus velocity is square dependent. After a sufficiently small period of time dt we have new velocity v_1 and therefore new ARF. When an object falls through the air, the ARF is increasing with square and therefore decreasing its acceleration a. Furthermore, after certain period of time, velocity reaches terminal velocity $v_{t.}$

Methods are helpful for a moving object through the air with arbitrary initial velocity and slope. We have researched an inclined throw of object motion through the air. Total velocity, acceleration and trajectory were found by adding the vertical component of the velocity and the horizontal component of the velocity. Velocity, acceleration and trajectory dependences versus time are presented with graphs.

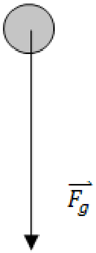
Our methods are useful for researching falling objects and projectile motion, because it is impossible to do it in nature or in laboratories. Programs are based on Wolfram Mathematica.

The plane of the paper is as follows. In Section 2 we compare free fall and inclined throw without and with impact of ARF. In Section 3 we explain methods to solving these tasks. Section 4 contains results and analysis.

Theoretical Approach

Free fall

Free fall is any motion of an object where gravity $\vec{F_g}$ is the only force to acting upon it (Fig.1). We know, that $F_g = mg$, where g ≈ $9.8\ m/s^2$ is acceleration of gravity, and *m* mass.



Velocity of a free falling object is

$$v = gt \tag{1}$$

and

$$h=(gt^2)/2 \tag{2}$$

is the distance of falling.

Figure 1. A free falling object. The object is falling free with acceleration g.

Free fall with air resistance

In presence of air we have other conditions. A falling object is under the influence of gravity force $\vec{F_g}$ and ARF $\vec{F_g}$ (drag force) in the opposite direction of an object's motion (Fig. 2). Velocity is smaller than in free fall and after certain period of time it reaches terminal velocity v_t.

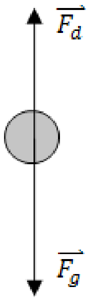


Figure 2. Falling object in the air. The falling object is under the influence of $\vec{F_g}$ and $\vec{F_g}$

The falling object is under influence of force $F = F_g - F_d$. The drag force F_d increases with v^2, because

$$F_d = (\rho \cdot v^2 \cdot c_d \cdot S) / 2 \ , \tag{3}$$

where c_d is the drag coefficient, ρ is the density of the air, v is the velocity of the object, and S is the cross sectional area.

Inclined throw

Object motion in vacuum

For an inclined throw in the vacuum initial velocity v_0 and the launch angle α with respect the horizontal are important. As we see in Fig. 3, v_0 consists of horizontal $v_x = v_0 \cos\alpha$ and vertical $v_y = v_0 \sin\text{-}gt$ components.

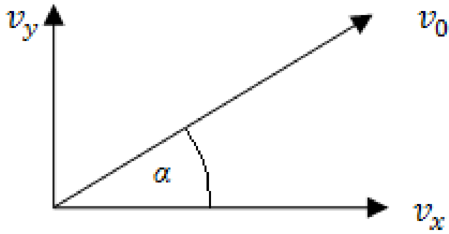


Figure 3. Split initial velocity v_0 on horizontal v_x and vertical v_y components.

Let (x,y) be position in plane of object after time period t. Thus

$$x = v_0 t \cos\alpha \quad \text{and} \quad y = v_0 \sin\alpha - (gt^2)/2. \tag{4}$$

From these expressions follow the time for the maximum high, the maximum height attained, and the horizontal distance travelled named range which are given by

$$t_{top} = (v_0 \sin\alpha)/g, \quad y_{max} = (v_0^2 \sin^2\alpha)/2g, \quad x_{max} = (v_0^2 \sin 2\alpha)/2. \tag{5}$$

Trajectory of motion by ignoring air resistance is parabola (Fig. 4). The maximal range in x direction is by angle of incline $\alpha = 45^o$.

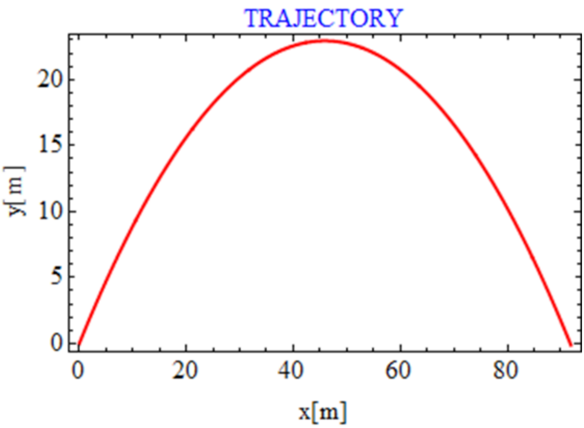


Figure 4. Trajectory of motion an object in the absence of air. The curve is parabola and is symmetric.

Motion through the air

By a small velocity the ARF is negligible. ARF versus velocity is square dependent and by largest velocity ARF has very important influence on object motion. It is much more difficult to solve this task than solving free fall under the influence of air resistance. We will solve this problem with numerical methods by taking into account the impact of air resistance on horizontal and vertical components. In our study of inclined throw, the impact of ARF against gravity force is neglected, because it will be hard for students in high schools. It is possible by small heights in y directions for an iron ball with adequate parameters.

Numerical simulations

Free fall with air resistance

The object is falling through the air and as we see in Fig. 3, on it are acting $\overrightarrow{F_g}$ and $\overrightarrow{F_d}$. From Eq. 3 we give $F_d = m \cdot [(c_u \cdot S \cdot \rho)/2m] \cdot v^2$, (6)

where $a' = [(c_u \cdot S \cdot \rho)/2m] \cdot v^2$ (7)

presents deceleration due to ARF. Therefore $F_d = a \cdot v^2$. (8)

Velocity of a falling object with air resistance is changing, and therefore air resistance force (ARF) is changing too. The difficulty is that ARF versus velocity is square dependent. After a sufficiently small period of time *dt* we have new velocity v_1 and therefore new ARF. When an object falls through air, the ARF is increasing with square and therefore is decreasing acceleration. After certain period of time, velocity reaches terminal velocity v_t.

We used a small enough time interval dt and calculate new velocity v_1. We did it with small intervals *dt* through arbitrarily long distance or sufficiently good approximation to reach terminal velocity v_t. To solve this task, we used numerical simulation. Figure 5 show the loop in program which solve this problem.

```
For[k = 1, Abs[v - vo] > 0.1, k++{

    v1 = (g - α vo^2) dt;
    h1 = (vo - v1) dt ;
    a = v1/dt;
    hr = g t^2/2;
    vo = vo + v1;
    ho = ho + h1;
    t = t + dt;
  }];
```

Figure 5. In the loop v_0 is initial and v_1 the new velocity. Factor α presented α' (Eq. 7). In the next step v_0=v_1 and so on.

Program for free fall with air resistance in Mathematica shows Appendix 1.

The motion with air resistance

To solve the motion in the air we split initial velocity v_0 on the horizontal component v_x and the vertical component v_y. Furthermore, we split drag force in x and y direction. Drag force acts on opposite site of motion on components v_x and v_y. Then we solve our task by components in small enough time intervals dt, similar as by free fall with air resistance.

Results

In our experiments we use an iron ball with diameter *2 cm*, $c_d \approx 0{,}4$, $S \approx 0{,}0003\ m^2$, $m \approx 0{,}033\ kg$, dencity of air $\rho = 1{,}2\ kg/m^3$ and $g = 9{,}81 m/s^2$. We also assume, that motion is without rotation.

Free fall with air resistance

Figure 6 shows increase of velocity to reach terminal velocity (dashed line). Right side shows the decrease of acceleration.

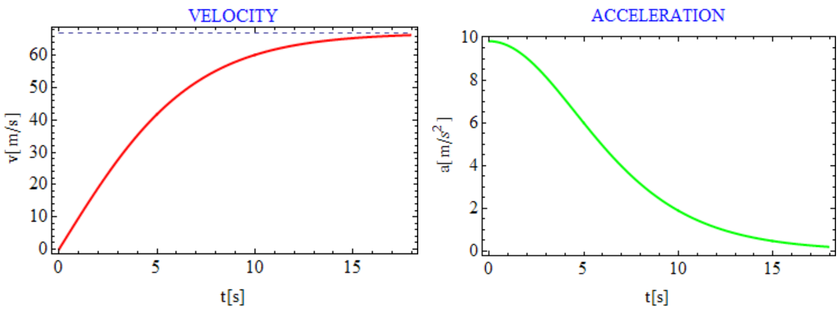


Figure 6. Velocity and acceleration vs. time.

Terminal velocity v_t is independent on initial velocity v_0. In all cases, if $v_0 > v_t$, $v_0 < v_t$, and $v_0 = v_t$, after certain time period velocity decrease v_t.

Motion with air resistance

In presence of air, trajectory of motion for an inclined throw is not a symmetric curve. In Fig. 7 we see trajectories for initial velocity $v_0 = 30\ m/s$ for different angles of the incline.

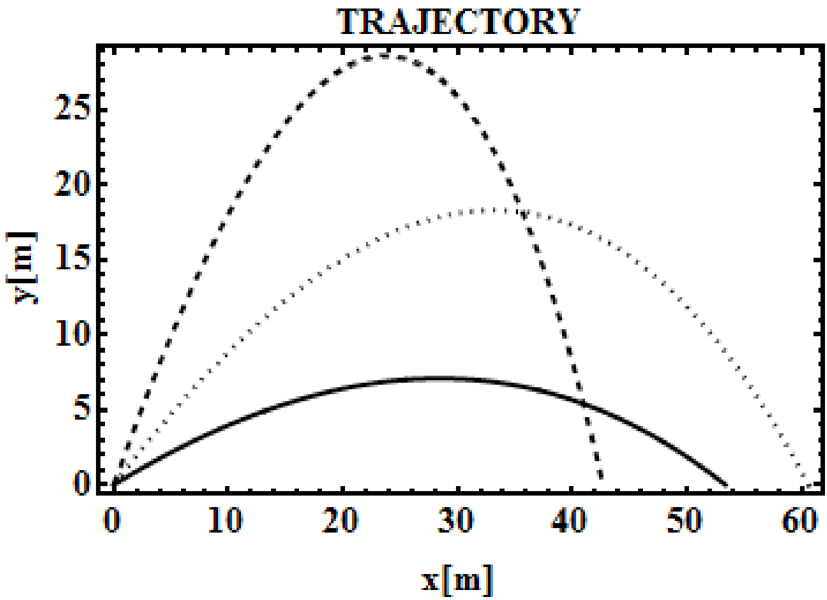


Figure 7. Trajectories of motion with three different angle of the incline (full line:25^o;dashed line 45^o;dotted line; 65^o) and v_0=30 m/s.

Figure 8 presents velocities for different angle of incline for trajectories from Fig.7.

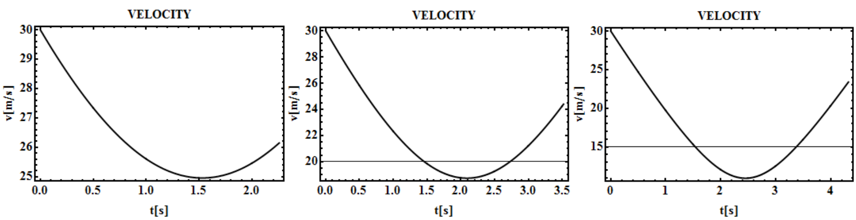


Figure 8. Velocities of motion with three different angle of the incline (25^o;45^o;65^o) and v_0=30 m/s.

For largest initial velocities the curves of motion are more antisymmetric. Fig. 9 presents motion of a ball with v_0=200 m/s. The first part of the curve is good approximation of a straight line. The length of the straight part increases with increasing initial velocity.

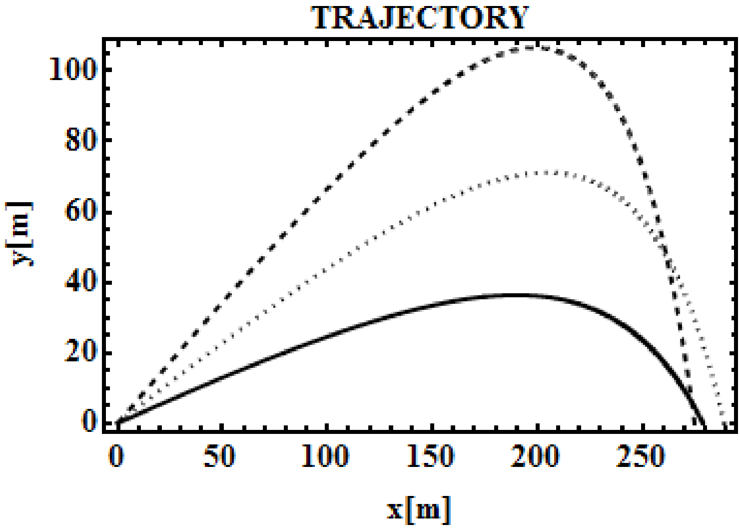


Figure 9. Trajectories of motion with three different angle of incline (full line:15^o;dashed line: 25^o;dotted line:35^o) and v_0=200 m/s.

For projectile motion under the influence of air resistance, the maximal range in *x* direction is by an angle below *45^o* (Fig. 10).

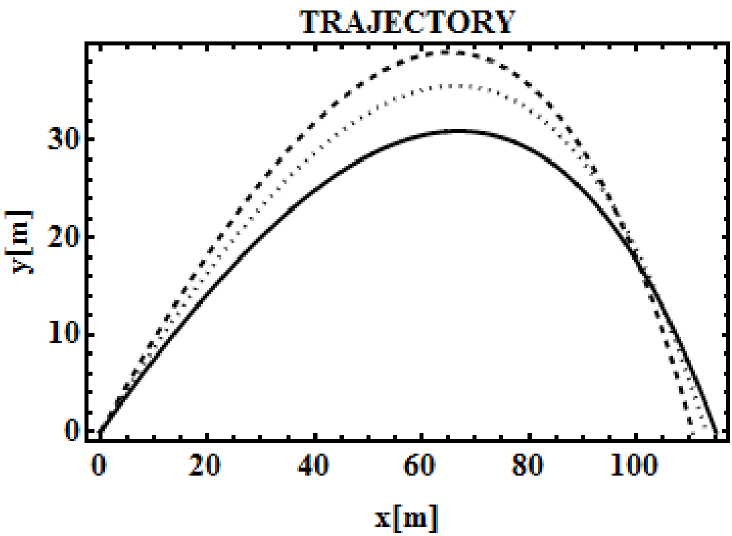


Figure 10. Trajectories of motion with three different angle of incline (full line:38^o;dashed line:42^o;dotted line:45^o). The maximal range in not by an incline angle 45^o as in the vacuum.

Conclusion

In our study we research motion under the influence of air resistance. By them we use numerical methods and computer simulations. Our results are a good enough approximation according to real situation. We used a time intervals of 0.001s. When we need better approximation we can use an even smaller time intervals. Helpfully, equations are expressed mathematically. Impact of air on an object in motion is negligible by small velocities with respect drag coefficient.

For a falling object through the air velocity increases and after certain time period it reaches terminal velocity v_t. When initial velocity $v_0 > v_t$, then it decreases to reach v_t, and when $v_0 = v_t$ then velocity will be constant. These interesting features of motion through the air occur because ARF is square dependent of velocity. Furthermore, when $v_0 < v_t$, acceleration decreases until it reaches zero, and for $v_0 > v_t$ we have a deceleration until it reaches zero.

We describe motion of an inclined throw with coordinates (x,y). For object motion under the influence of air resistance, we split velocity into horizontal and vertical v_y components. The ARF acts in the opposite site of motion. We use, that ARF acts on the horizontal part of motion (v_x) and on the vertical part (v_y). The trajectory of motion is a symmetric parabola for an inclined throw without air. In presence of air the curve of motion is not symmetric any more. Note, that we need to respect the drag coefficient and other parameters. At the beginning of the motion the curve of motion is similar to a straight line. By increasing the initial velocity the length of a straight line increases in the first part of motion. It is important for projectiles. They need to have high initial velocity for moving in a straight enough line to hit the target. The interesting finding in our study is that the maximal distance to reach the projectile in horizontal (x) direction for an inclined angle is above 45^{o}.

In the future it will be interesting to continue researching maximal distance in the x-direction and its dependence from other parameters. In our study, the impact of ARF against gravity force is neglected.

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APPENDIX

Appendix 1: Computer program for falling object with respect the air resistance.

```
Clear["Global`*"];
TableForm;
(*Parameters*)
n = 5000; dt = 0.01; m = 0.033; g = 9.81; cu = 0.4; S = 0.0003; ro = 1.2;
vz = 0;
α = (cu S ro)/(2 m);
h1 = 0; a = 0; h = 0; t = 0; vi = 0;
v = Sqrt[(2 m g)/(cu S ro)];
mm = Table[c, {i, 1, 2}, {j, 1, n}];
mm1 = Table[c, {i, 1, 2}, {j, 1, n}];
mm2 = Table[c, {i, 1, 2}, {j, 1, n}];
mm3 = Table[c, {i, 1, 2}, {j, 1, n}];
Print["v final = ", v, "    h max. =   ", h];
vo = vz;
For[k = 1, Abs[v - vo] > 0.7, k++{

    v1 = (g - α vo^2) dt;
    h = ((g - α v1^2) t^2)/2;
    a = v1/dt;
    mm[[1, k]] = t; mm[[2, k]] = vo;
    mm1[[1, k]] = t; mm1[[2, k]] = v;
    mm2[[1, k]] = t; mm2[[2, k]] = a;
    mm3[[1, k]] = t; mm3[[2, k]] = -h;
    vo = vo + v1; t = t + dt;
  }];
s11t := ListPlot[Transpose[mm], Joined → True, PlotStyle → {Thick, Red}];
s12t := ListPlot[Transpose[mm1], Joined → True, PlotStyle → Dashed];
s13t := ListPlot[Transpose[mm2], Joined → True, PlotStyle → {Thick, Green}];
s14t := ListPlot[Transpose[mm3], Joined → True, PlotStyle → {Thick, Blue}];
Show[{s11t, s12t}, Frame → True, FrameLabel → {"t[s]", "v[m/s]"}, AxesLabel → {"t[s]", "v[m/s]"},
 FrameStyle → Directive[Black, 16], PlotLabel → Style["VELOCITY", Blue, 16], PlotRange → {0, vo + 1}]
Show[{s13t}, Frame → True, FrameLabel → {"t[s]", "a[m/s^2]"}, FrameStyle → Directive[Black, 16],
 PlotLabel → Style["ACCELERATION", Blue, 16]]
Show[{s14t}, Frame → True, FrameLabel → {"t[s]", "h[m]"}, FrameStyle → Directive[Black, 16],
 PlotLabel → Style["HEIGHT", Blue, 16]]
```

Opinions of Junior Secondary School Pupils About Factors Influencing Effective Learning of Chemistry

The context and purpose of the framework

Chemical knowledge is an essential constituent of education of every man though it is believed that there is drop in interest in science subjects. Pupils' approach to the subject being learnt depends largely on motivation. It decides whether the child's work is self-dependent or he or she learns because of the needs inherent in him/her or requires encouragement from others. Teaching outcomes also depend to a large extent if the pupil enjoys learning, displays interest in acquiring knowledge has sense of duty, need to understand knowledge and whether he or, she perceives relations between the acquired knowledge and his future plans, and aspirations (Reykowski, 1977). At present chemistry learning effects are not satisfactory. Generally, chemistry is believed to be a very difficult subject to learn and fewer and fewer pupils decide to take chemistry as a senior secondary final exam and as a major of studies. The aim of the paper was to determine the factors influencing effective learning of chemistry by junior secondary school pupils. Knowledge of these factors will allow taking actions aiming at improvement of pupils' approach towards learning chemistry. Developing pupils' interest in the knowledge acquired during the chemistry lesson a constitutes one of the basic and most important objectives. Achievement of this objective is decisive of accomplishing other education aims. It also affects the process of chemical knowledge acquisition and pupils' achievements. There is the relation between the pupils' interest in the subject and motivation for learning. The question arises: How to develop pupils' interest during the chemistry lesson? of significant importance is teacher's work. His knowledge engagement and behavior should arouse pupils' interest in learning the subject. Moreover, he should make an attempt to get to know pupils' possibilities and interests, which they acquired in the initial stage of learning and out of school. Teacher's duty is also to take care so that choice of information and teaching methods will not surpass pupils' intellectual and technical possibilities resulting in failure and learning unwillingness (Burewicz & Gulińska, 2002). The greater pupils' interest will be, the more convinced they will be that knowledge acquired during chemistry lessons is of practical implication. If they get proof that it is not knowledge only for initiators but refers to substances and processes they come, across every day, they are sure to create new problems and solve them. Pupil's interest is most often a product of belief that some knowledge or skills can be useful for achieving aims, which, in his opinion are important (Nodzyńska, 2005). Interests originate also from curiosity and willingness to acquire some more knowledge about things they have minimum knowledge and came across earlier. Such pupils can show special interest in chemistry realizing that school is not the only though main source of knowledge. This, in turn, will form skills of their independent learning through: searching information in extra books, magazines, television programs, and the internet. Pupils can also broaden their knowledge depending on needs connected with development of their interests e.g. participating in chemical workshops displays, interest circles organized at schools or universities (Augustyniak & Kloc 2004). Teachers often make a decision to work individually with the pupil, encouraging him to take part in competitions or chemical contests. Homework is an indispensable element of educational process and its importance is not to be overestimated. To obtain positive effects of homework, the teacher's role is essential. This job is to provide reversible information for the pupil and point out what was done correctly and explain what was not familiarized (Walberg & Paik, 2002). Homework properly made use of by the teacher has great influence on effective pupils' learning. While doing homework, pupils learn some facts and notions create skills of critical thinking, develop proper attitudes and habits. Another advantage of homework is the fact that less talented pupils, spending more time learning at home, can get marks similar to those obtained by more capable ones (Kamińska-Ostęp, 2011). Besides that positive effect on pupils' achievements, homework:

- creates a habit of learning at home,
- prepares pupils for individual learning,
- enables parents to see what their child learns at school
- extends time of organized learning beyond that spent at school,
- enables pupils' reflection on the things learnt at school and more through learning than it is possible during the lesson
- allows the teacher for more frequent checking of pupils' achievements.

Time spent on doing homework is a certain way of learning time prolongation and increasing achievements. Though it should be remembered that achievements largely depend on quality of the done work. In order to diminish their work load connected with marking pupils' homework, teachers can employ pupils who will use procedures according to which they estimate and mark each other's papers (Walberg & Paik, 2000). In this way they also learn collaboration and estimation of the own work and that of others. Quality of homework is as important as its quantity. Effectiveness of homework does not increase proportionally to the number of asked questions but is more connected with regularity of their application as well as their kind. Of significant importance is also teacher's interest if pupils cope with their homework. Well planned it is closely connected with the lesson content and adjusted to pupils' capabilities (Walber & Paik, 2000). Homework is the most effective when it is:

- often given,
- directly connected with the subject discussed during the lesson,
- used rather to develop knowledge than to learn new material,
- evaluated and considered as an essential element of final evaluation of pupils' work,

- marked in a short time after collecting it with some commentaries vital for a given pupil (Kamińska-Ostęp, 2010).

Methods

In the paper there was applied the survey with the research tool, in the form of questionnaire including 25 open closed and semi-open questions, thematically divided into a few parts. The first part of the survey concerned pupil's motivation and interest in learning chemistry. The questions had to investigate pupils' attitude to learning chemistry comparing the knowledge at the beginning of learning and that while the questionnaire was being filled. Moreover, it was essential to learn what factors affected pupil's interest in chemistry. The second part of the survey includes the questions aiming at obtaining information about the course of chemistry learning process, more precisely about current ways of checking acquired knowledge preferred by pupils of junior secondary school and whether or what connection it has with the cognitive system. The next part deals with chemistry lessons at school. The questions aimed at getting information how pupils evaluate chemistry lessons and what their expectations are concerning the teaching methods and aids facilitating learning chemistry applied by the teacher. The fourth part includes the questions concerning homework. The questions are to show whether pupils regard homework necessary in the education process or nor. Of significant importance was checking whether young people do it systematically and what are the reasons that it is not always done. The additional objective is obtaining the information what kind of homework is prepared by the junior secondary school pupils. Three municipal and three rural schools of Lublin were chosen for the survey taking into consideration the results of the science subject part. 384 pupils – 229 from municipal schools and 155 from rural ones took part in the survey.

Results

The answers obtained from all questioned pupils were added up and converted into percentage. The obtained data will be presented in the form of graph with commentary. In the legends if diagrams (r) means the percentage of the answers obtained from rural school pupils (color dark gray bars) and (m) indicates the percentage of the answers obtained from municipal school pupils (light gray bars).

Answering the first question the pupils were to define their attitude towards the subject – chemistry at the beginning of junior secondary school and at present. As follows from the analysis, the attitude of junior secondary school pupils towards learning chemistry was and still is positive (Fig. 1). It can be seen that pupils in the surveyed municipal schools have better attitude than those from rural schools. As many as 35% of the questioned pupils from the rural schools stated that their attitude changed from positive into negative whereas only 18% of municipal school pupils gave such answer. The evidence that pupils' attitude can change is the fact that 24% of municipal school pupils stated that their attitude changed from negative to positive.

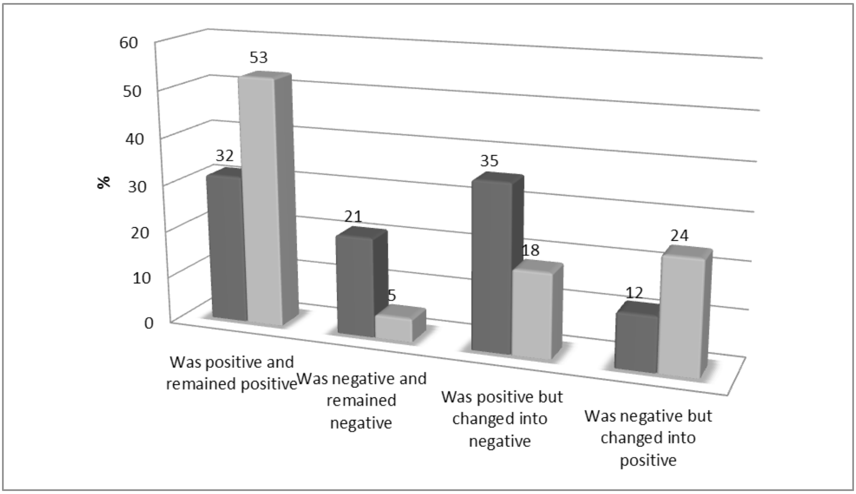


Figure 1. Junior secondary school pupils' attitude towards the subject – chemistry

Then the pupils were asked if they are interested in chemistry as a school subject. The results are presented in Fig. 2. 43% of rural school pupils answered that they are interested in this subject whereas 66% of municipal school pupils showed interest in it. However, 57% of rural school pupils and 34% of those living, in the town are not interested in chemistry as a school subject.

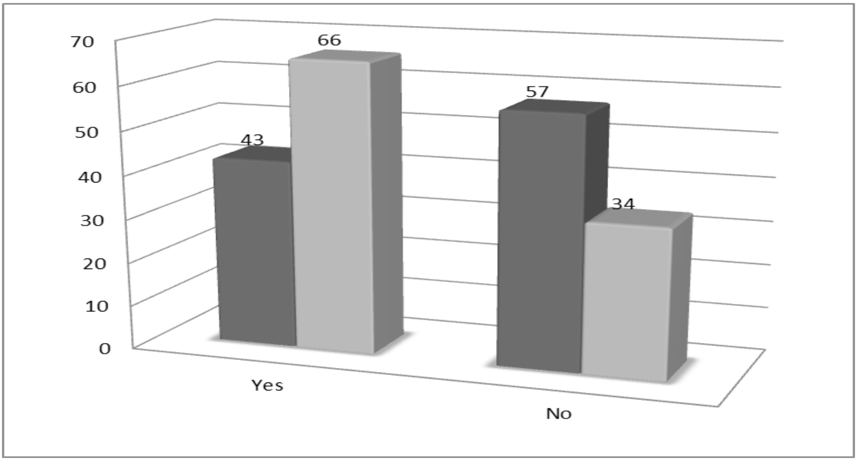


Figure 2. Pupils' interested in chemistry

As for question three it was essential to obtain information whether pupils are able to take any additional activity to boost they interest in the subject (Fig. 3). The answers of pupils from the rural schools were fifty-fifty: half the pupils would like to take up such activities but the other half does not see any need to do it. Whereas 64% of pupils from the municipal secondary schools would take up such activity and 36% of pupils gave to negative answer.

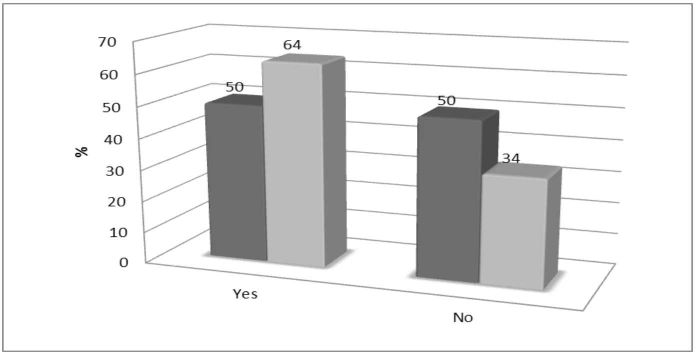


Figure 3. The wish to take additional activities by pupil.

The pupils who gave the positive answer were asked to choose the activities they would take to boost their interest. The chosen activities were similar for both municipal and rural school pupils (Fig. 4).

1. out of school forms of education
2. circles of interest
3. computer educational programs
4. TV educational programs
5. chemical experiments

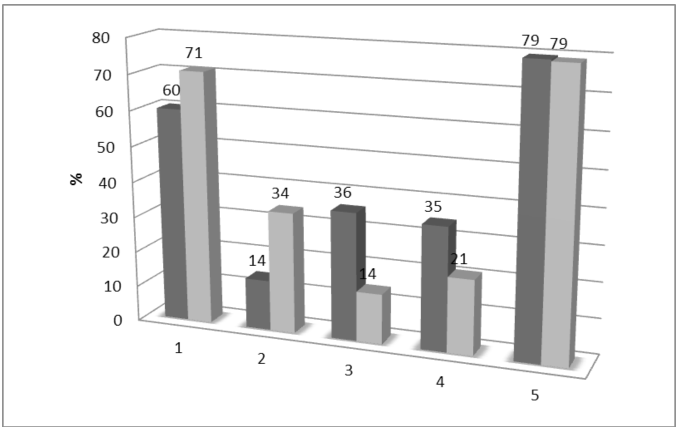


Figure 4. Activities which pupils would like to take to boost their interest in chemistry

The pupils are most willing to conduct chemical experiments and take advantage of out of school forms of education such as e.g. trips to the Copernicus Centre of Science, Science Festivals etc.. The rural school pupils are the least willing to take part in circles of interest are the least willing to take part in circles of interest (14%). However, for 34% of municipal school pupils participation in circles of interest affected positively their interest in chemistry. Using computer and television educational programs was chosen by about 36% of rural school pupils. They believe that these activities would affect their interest in chemistry positively. This may result from the fact that the young do not have access to the computer or the Internet and are not aware of their effect on the interest in this subject. The pupils from the chosen rural schools state that the computer educational programs have the smallest effect on their interests (14%). Answering the next question whose aim was to determine the cognitive style from the give definitions, distinctly a larger number of pupils proved to be visualizers (53% of pupils from municipal schools and 42% from rural schools). However, 32% and 25% of pupils respectively stat that they are audiles. Kinesthetic are in the smallest number: 27% and 22% of pupils respectively believe that they learn in the way typical of this cognitive style (Fig. 5).

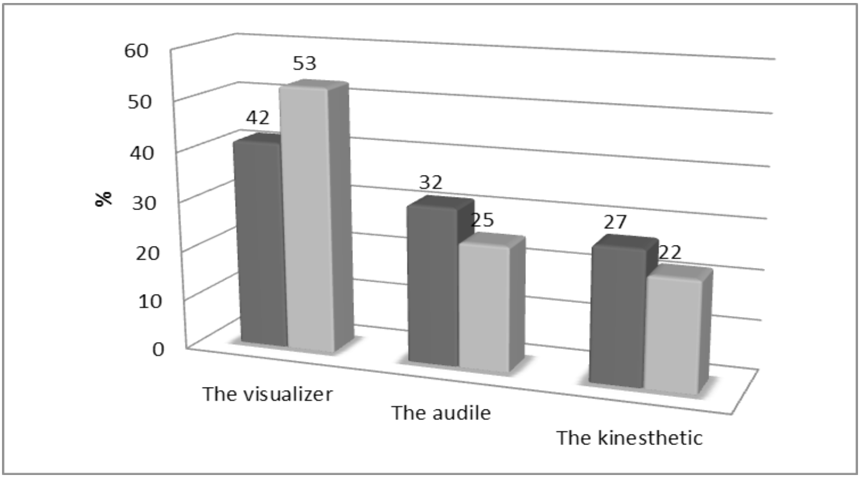


Figure 5. Cognitive styles of pupils

The fifth question required choice of the ways promoting concentration during learning (Fig. 6). The largest number of pupils from both municipal and rural schools (48% and 44% respectively) answered that repetition in thoughts promotes acquiring knowledge. The second position was "speaking loud" chosen by 30% of rural school pupils and 27% of municipal school pupils. To underline the most important information different colors are used by 15% or rural school pupils and 21% by municipal school pupils.

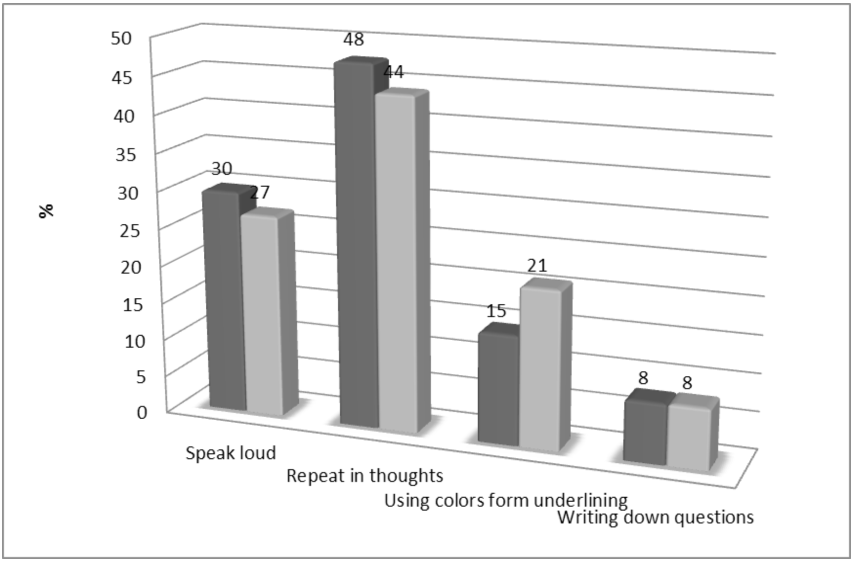


Figure 6. Activities assisting concentration during learning

The sixth question aimed at determining pupils' individual ways of learning. Analyzing their ways of learning it can be stated that pupils hardly ever use computer programs and do not create conception or associational maps. They sometimes read theory from the school-book or notes from the exercise book, solve tasks, make their own notes or use the additional materials and books. They often read only notes made during the lesson or theory from the school-book but do not spend time solving tasks. Moreover, they often rely mainly on what they remembered during the lesson. Similarly, they learn formulae, definitions and laws by heart. However, they state that while learning they always use the Internet. It was also essential to get to know the average pupils' favorite form of learning (Fig. 7). As follows from the obtained answers, both rural and municipal secondary school pupils, who took part in the survey, learn most readily at home (31% (r) and 37% (m)). 32% of the young from rural schools and 27% from municipal schools shoved preferences for learning during the lesson. The answer that they do not like learning during extra activities (circles of interest) was chosen by only 2% or rural school pupils and 3% of municipal school pupils. Those from rural schools prefer learning in the group – 24% and individually – 11%. For the pupils of chosen municipal schools these both forms of learning are almost equally important 15% for learning in the group and 18% for individual learning.

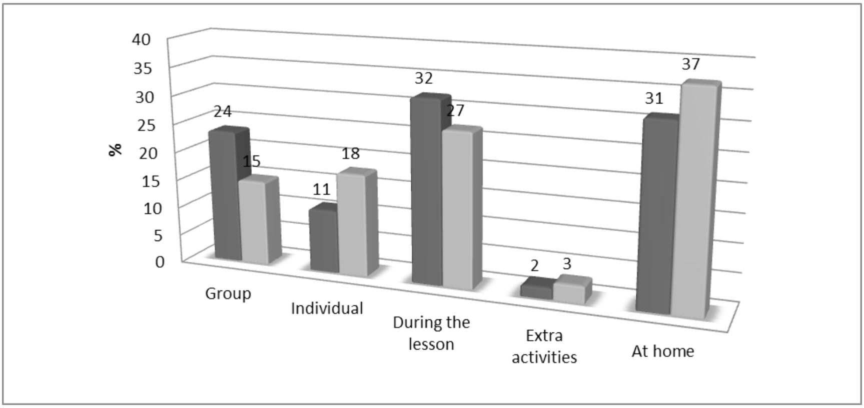


Figure 7. Forms of learning preferred by junior secondary school pupils

When answering the question "Is individual learning chemistry difficult for you?" 48% of rural school pupils ad 43% of municipal ones answered that these difficulties depend on the material presented at school. Permanent learning difficulties were revealed in 6% of pupils in rural schools and 3% in those attending schools in town (Fig. 8).

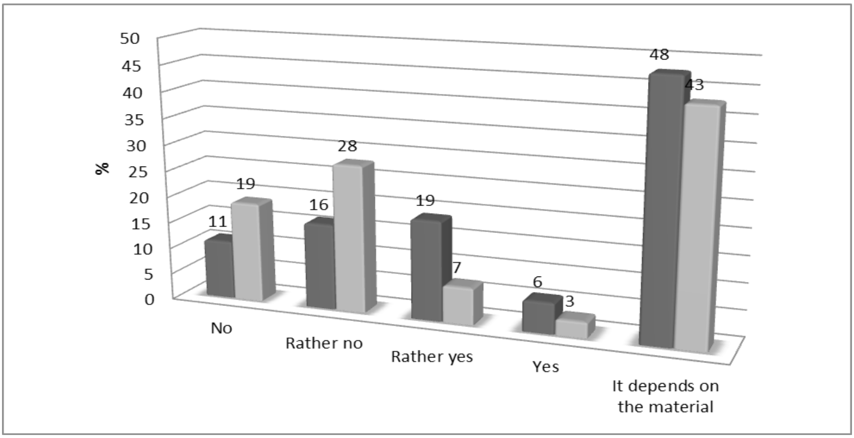


Figure 8. Determine the degree of difficulty of students from independent science chemistry

It was important to study how often pupils prepare for chemistry lessons (Fig. 9). 34% of the young people attending schools in the village and 30% of those attending schools in the town learn for the lessons only from time to time, 21% and 28%, respectively only for tests. Regular learning at home was revealed by only 17% of rural school pupils and 15% of municipal school pupils.

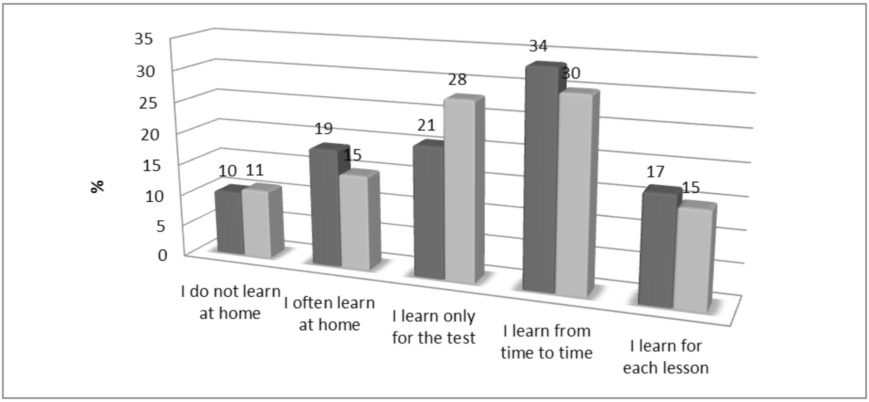


Figure 9. Frequency of pupils' learning at home

The next question was if the way of conducting chemistry lessons at school is interesting (Fig. 10). The most frequently chosen answer was "rather yes" (32% and 34% of pupils from rural and municipal schools respectively). As many as 28% of pupils attending rural schools found chemistry lessons not interesting. However, the contrary answer (29%) was given by those attending schools in the town.

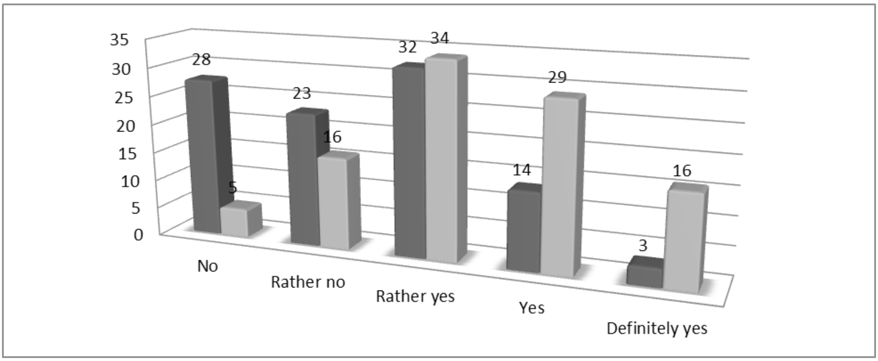


Figure 10. Presentation whether the way of conducting chemistry lessons is interesting for pupils

The pupils' choice of the most relevant description of the lesson is as follows:

- The class is observing the experiment made by the teacher or the pupil, is listening to the teacher's lecture, is watching a film/ presentation and making notes 38% (r), 49% (m).

- The teacher is conducting the discussion about the subject of the lesson, is describing and explaining given processes and giving a task to perform using the book – 60% (r), 44% (m)

- Being given a task pupils in groups or individually are performing experiments, working using models and solving problems – 3% (r), 7% (m).

According to most rural school pupils, chemistry lessons in most cases include teacher's discussion about teaching contents description and explanation of about teaching content, description and explanation of the processes associated with them and giving tasks to be done using the school book. However, the municipal school pupils a different average chemistry lesson. The class is observing the experiment performed by the teacher or pupil, is listening to the lecture, watching a film or presentation and making some notes. Only a few percent of both rural and municipal school pupils marked the description of the lesson at which pupils are performing experiments, working in groups, solving research problems and using such didactic as e.g. molecular models. This indicates that not many didactic aids are employed during chemistry lessons. Answering the question about the form of checking knowledge preferred by them, 56% of rural school pupils chose a test with closed tasks. This form was also favored by 63% of municipal school pupils whereas 21% chose a brief test.

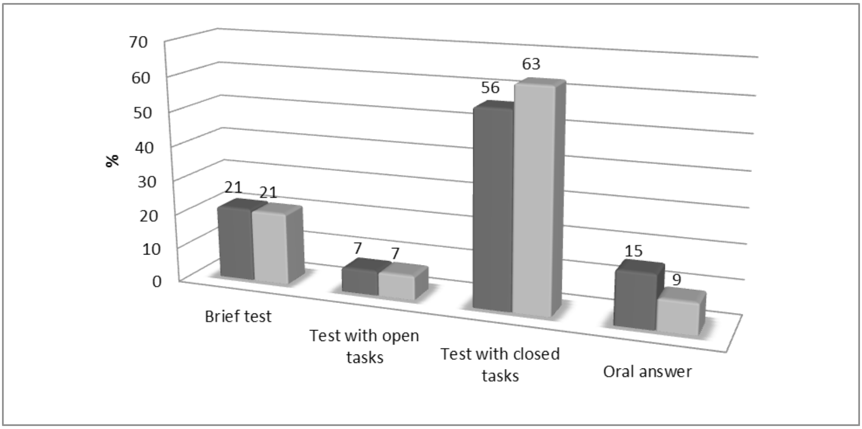


Figure 11. Preferred forms of checking knowledge

To obtain more information about preferred forms of checking knowledge, the pupils were asked about type of tasks they like solving (Fig. 12) It is not surprising that 56% of non-municipal school pupils and 39 of municipal ones chose tasks with given answers. The tasks requiring long answers are the least popular (chosen by 1% and 4% of pupils from rural and municipal schools respectively). It also follows from the investigations that there is a great difference as regards the first answer: tasks of the "calculate" type. It was marked by 6% of rural school pupils and 19% of municipal school ones.

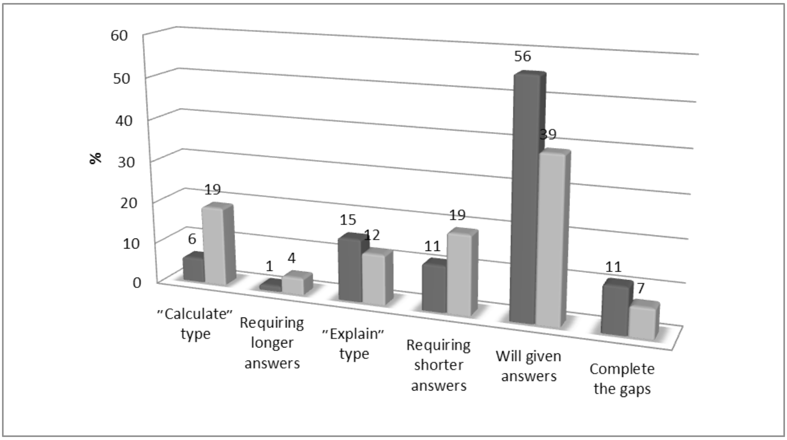


Figure 12. Preferences for the tasks to be solved.

Of essential importance was to study if pupils take advantage of activities performed outside of lesson hours in order to improve their chemistry achievements (Fig. 13). Almost half of the total number of surveyed pupils (45% from rural schools and 53% from municipal ones) answered that they do not take part in such activities because they do not want to. Only a very small number (3% from rural schools and 13% from municipal ones) participate regularly in such activities.

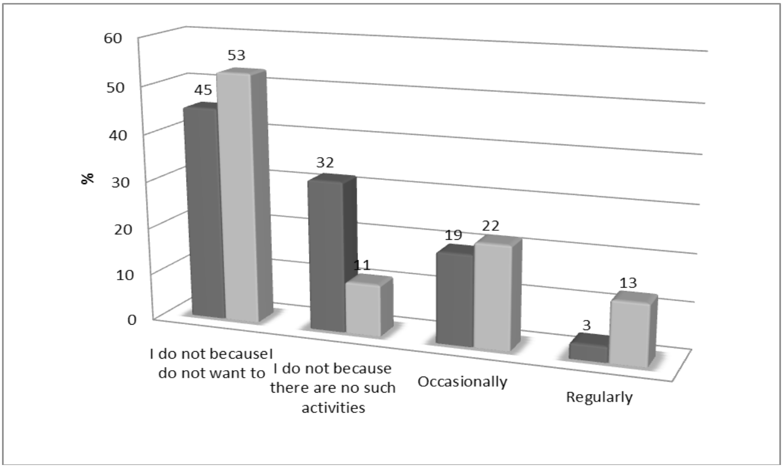


Figure 13. Wish of pupils' to attend activities performed outside of lesson hours.

Successive questions referred to the problem of homework (Fig. 14). As many as 62% and 67% of pupils from rural and municipal schools, respectively believe that homework is indispensable in the educational process.

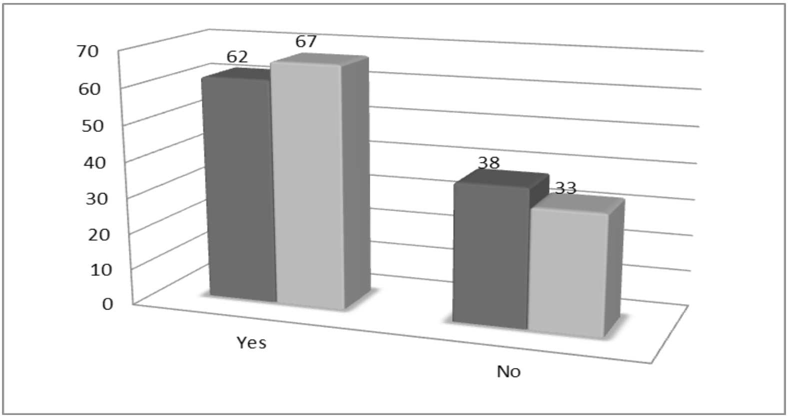
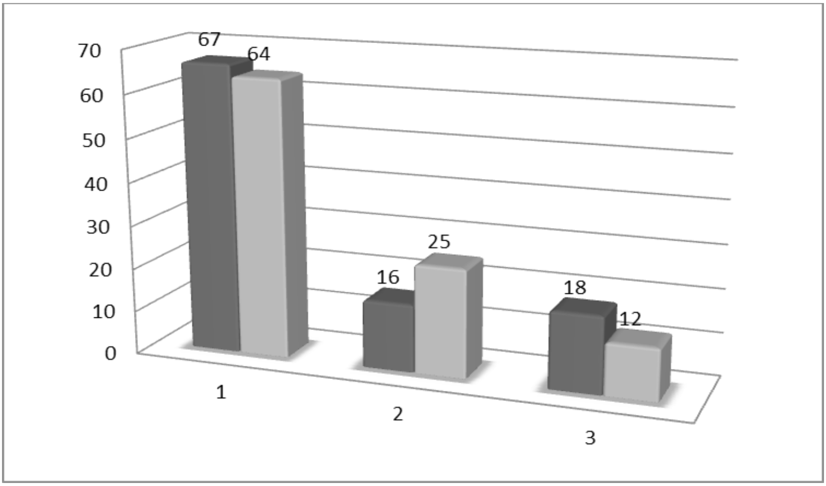


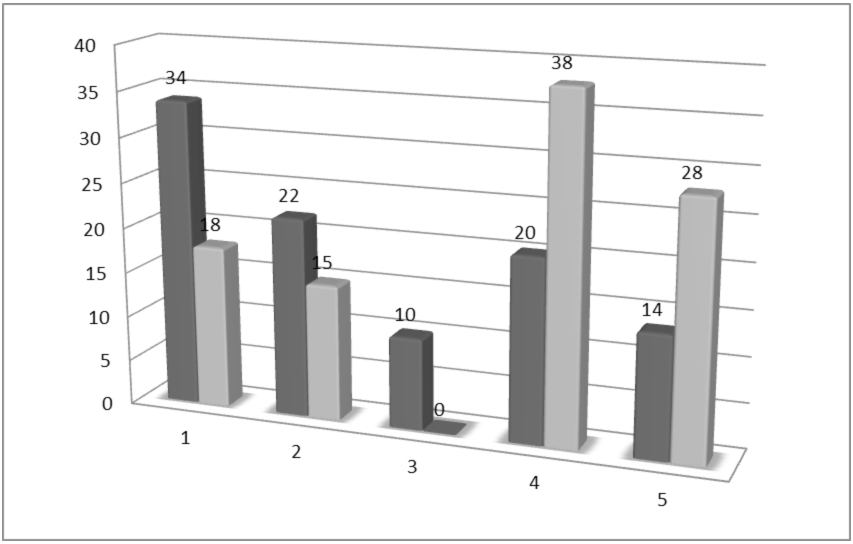
Figure 14. Evaluation of homework applicability in the educational process

The answer ″Yes″ about applicability of homework had to be justified. 67% of pupils from rural schools and 64% from municipal ones believe that homework helps consolidate the knowledge acquired during the lessons. 25% and 16%, respectively believe that homework helps systematize their knowledge. The other pupils are of the opinion that doing homework is a good way to prepare for tests (Fig.15).



1. Homework allows to consolidate the acquired knowledge as it is often as associated with recalling to mind
2. Homework allows to systematize knowledge acquired earlier
3. Homework allows to revise for tests
Figure 15. Opinions of junior secondary school pupils about homework.

Those who answered "No" to the question if homework is indispensable in the educational process were asked to justify their reply. The most frequent answer chosen by 34% of rural school pupils was that "it is difficult and discouraging" but 22% of municipal school pupils believe that homework is "almost always the same, that is why it is boring". The smallest number (10%) of the pupils thinks that the homework "sometimes goes beyond the contents presented in the school book". No such answer was marked by the pupils attending the schools in town. The largest number that is 38% of the young from municipal schools chose the answer. Its doing demands devoting some out of school hours. According to 28% of pupils the homework is not necessary as "it is often done carelessly, rather copying the school book". The data show that the homework in the surveyed schools is not exploited as an important element of educational process (Fig. 16)



1. Homework is difficult and discouraging
2. Homework is almost always the same, that is why it is boring
3. Homework sometimes exceeds the school book contents
4. Doing homework needs spending some out of school time
5. Homework is often done carelessly just copying the school book
Figure 16. Effects of homework on the educational process.

In reply to the question "Do you do your chemistry homework systematically?", the answer "Yes" was given by 61% of rural school pupils and 73% of those attending the schools in town. The other pupils (39% and 27% respectively) admitted not doing the homework systematically (Fig. 17).

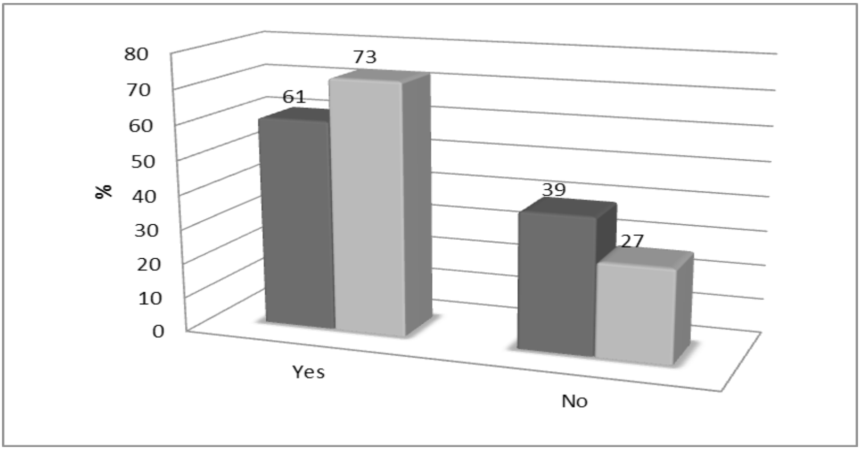


Figure 17. Regularity of doing the homework by junior secondary school pupils

To study the reason for irregular doing homework there was asked the question "what is the most frequent reason for not doing your homework regularly" (Fig. 18). The largest number (33%) of rural school pupils does not do their homework regularly because they often do not know how to do it. A similar reason for neglecting doing the homework is given by 24% of municipal school pupils. The same number of pupils from these schools considers that laziness is the main reason. There is a smaller number (18%) of "lazy" rural school pupils. 31% of pupils from these schools do not often do the whole assigned homework because they cannot do everything. The same reason is given by 25% of pupils attending the schools in town. The above can suggest that the homework given to pupils is more difficult than the problems or tasks being solved during the lesson as well as insufficient explanation by the teacher. Moreover, 3% of the young learning at village schools and as many as 12% attending the schools in town state that doing the homework is meaningless because it is not checked by the teacher.

1. I do not frequently know how to do everything
2. I do not frequently understand what to do and how
3. It is too much
4. I am lazy and I do not even check it I can do it
5. I do not see any point in doing the homework because it is not checked

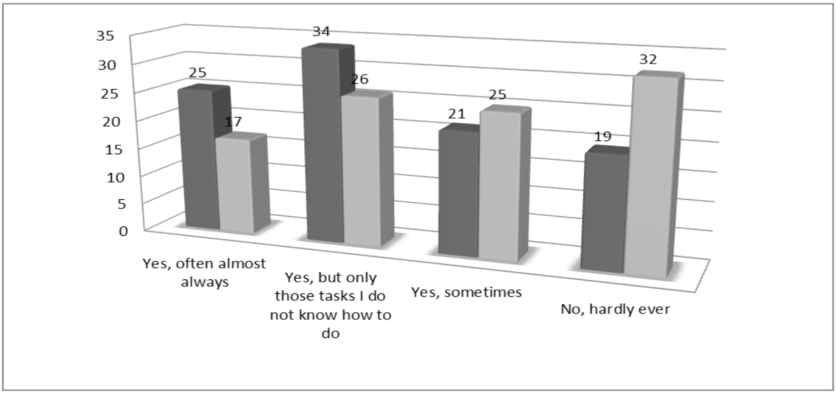


Figure 18. The reasons for not doing the homework by the junior secondary school pupils

Dealing with the subject of homework the pupils were asked how often they copy the tasks assigned for the homework (Fig. 19). The obtained answers were differentiated. A many as 32% of municipal school pupils answered they never copy it but only 19% of those attending the rural schools chose this answer. The largest number that is 34% of them copy only those tasks they are not able to do. The smallest number of municipal school pupils (17%) stated that they often or almost always copy the homework. The obtained data indicate that the main reason for not doing the homework is a lack of understanding or knowledge indispensable for doing it.

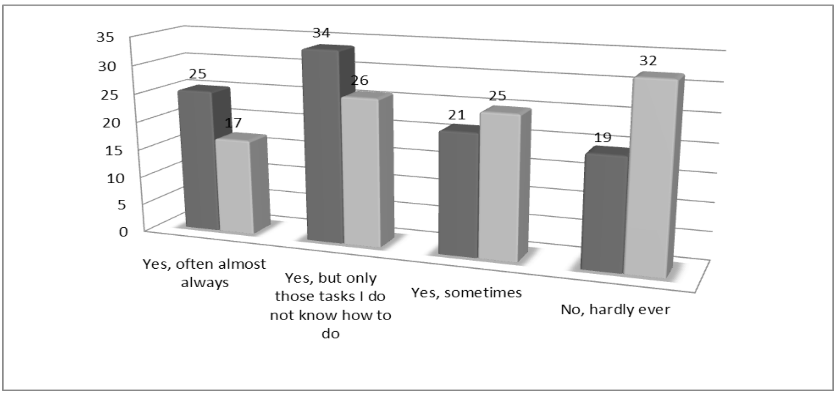


Figure 19. Frequency of copying the homework by junior secondary school pupils

In order to obtain more detailed information about this subject the junior secondary school pupils were asked what homework they would be eager to do individually. The most frequent answer was with "a small number of arithmetical tasks" -59% (r); 53% (m) and then:

- Tasks referring to everyday life – 49% (r) , 47% (m);
- With possibility of preparing interesting pieces of information about a given and acquainted subject – 44% (r), 34% (m);
- With possibility of performing experiments at home – 39% (r), 35% (m);
- In the form of posters or other artistic works – 34% (r), 25% (m);
- In the form of multimedia presentation – 27% (r), 31% (m);
- With a large number of arithmetical tasks – 6% (r), 14% (m)

The most willingly done homework includes performing experiments at home at doing tasks connected with everyday application of chemistry. As follows from the questionnaire the pupils had some evident problems or fears connected with arithmetical tasks because more than half questioned chose to do the homework with a small number of arithmetical task.

This may result from the problems connected with the use of mathematical operations which are indispensable for doing this type of tasks.

Conclusions and implications

The main objective of the research was determination of the factors influencing effective learning of chemistry by junior secondary school pupils. The additional aim was to diagnose possible difficulties and problems connected with learning chemistry. The junior secondary school pupils have positive attitude towards chemistry. This subject is more interesting for the pupils of municipal than rural schools. The pupils are ready to undertake additional activities to boost the interest in chemistry. These include among others, participation in out of school forms of education and conducting chemical experiment. The studies showed that junior secondary school pupils are not willing to take part in out of lesson circles of interest as well as school competitions developing knowledge. They are not fond of taking part in the team work but eager to do experiments individually. During learning individually they use the Internet, notes made by them, learn formulae and definitions but, rarely solve tasks. The reasons for possible difficulties and problems connected with learning chemistry can be searched for already in the stage of pupils' preparation for lessons. Junior secondary school pupils are not in the habit of learning regularly. They do it only from time to time. Un systematized basic knowledge in chemistry results in further problems connected with its learning. This is strengthened by pupils' unwillingness to do the homework. The fact is that they consider it do be boring, discouraging and difficult. They would like to do chemistry connected with everyday life. They are ready to prepare interesting information about the acquainted subject and conducting experiments at home. The studies show that pupils have difficulties with task solving. They do not want and are not able to do it as a result of poor mathematical abilities.

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Relevant Practices Developed by Teachers to Promote Student Motivation and Interest

"The real question is how one can get students interested in learning — more correctly, interested in learning those things that adults deem worthwhile. Seduction, I think." (Cardellini, 2002, p. 57)

Introduction

Despite the importance of education in the contemporary society, a common and old problem of education is to get students interested in learning. Many countries and schools are seeking to introduce paradigm shifts and new programs to address concerns related to a lack of relevance in school teaching. Science education share the same problems. In a report to the Nuffield Foundation, Osborne and Dillon (2008, p. 27) concluded "The irony of the current situation is that somehow we have managed to transform a school subject which engages nearly all young people in primary schools, and which many would argue is the crowning intellectual achievement of European society, into one which the majority find alienating by the time they leave school." According to Schreiner and Sjøberg (2004, chap. 4.2), there is falling interest in science and technology in the way it is being taught and studied at school. In a report to the European Commission it has been affirmed that many high school students "have a perception of science education as irrelevant and difficult" (Rocard et al., 2007, p. 9).

In an extended study about the school science curriculum, involving 144 students, 117 parents and 27 teachers, Osborne and Collins (2000) found that science was considered to be an important subject of study by all students and their parents, but that science education was valued by students only as a topic to achieve career aspirations rather than as a subject of intrinsic interest, and "The subject that attracted the most antipathy was, surprisingly, chemistry. This was seen as abstruse and irrelevant to contemporary needs." (p. 5) The lack of relevance most probably leads to both low levels of motivation and interest in chemistry, and can also be one of the reasons for the decline in enrolment in science courses in upper secondary and higher education. According to Aikenhead (2003, p. 115) the reason is that "chemistry and physics are irrelevant and boring, mainly because their instruction is out of synchrony with the world outside of school".

All this imply that different paradigm and interactions must be used in the classroom and possibly put in place a learning environment makes science learning more challenging and meaningful. An environment where teacher and students are involved with different roles, but with a shared 'project'. In this way the students will feel more and more involved and they will acting collectively as a "community of learners". (Gilbert, 2006)

Background: The European project

The main goal of the project PROFILES has been to promotes inquiry-based science education (IBSE) (Rocard et al., 2007; Bolte et al., 2011; Bolte, Holbrook & Rauch, 2012; Holbrook & Rannikmae, 2014) and aims to increase teachers' competence and to enhance scientific literacy of students, encouraging new approaches in science teaching (Holbrook & Rannikmae, 2007; Marks & Eilks, 2009; Higgins, Parsons, & Bonne, 2011). The task is to support teachers to create motivating learning environments by promoting an "education through science" approach (Holbrook & Rannikmae, 2007; Marks & Eilks, 2009). To change the teachers' practices in the classroom it is necessary to can change teacher's beliefs and teaching styles and that in many cases is a very ambitious goal. (Hofstein, Carmi, & Ben-Zvi, 2003) "The slow pace of reform in science education has been attributed to a fundamental characteristic of teacher beliefs: beliefs are stable and highly resistant to change." (Bryan, 2012, p. 488)

The importance of continuous professional development

Continuous professional development is shown to have a positive impact on teachers' sense of efficacy and their relationships with students. A programme of continuous professional development is a very complex task. "Continuing professional development (CPD) ... is a deceptively simple description of a hugely complex intellectual and emotional endeavour which is at the heart of raising and maintaining standards of teaching, learning and achievement in a range of schools, each of which poses its own sets of special challenges." (Day & Sachs, 2004, p. 3)

According to the philosophy of the PROFILES Project, the CPD must address "problems and issues in science education by guiding teachers to embrace a range of teaching factors, such as a context-based approach, motivational constructivist learning; student centred inquiry teaching; enhancing cognitive conceptualisation, and including socio-scientific decision making." (Holbrook & Rannikmae, 2014, p. 9) Achieve this goal and this level of professionalism requires a considerable commitment: experience has shown that it takes few years of practice and reflection on the results. To become leaders in education, a professional growth, a personal growth and a social growth is needed. "Social development involves learning to work with other people in the educational system in new ways." (Hofstein, Carmi & Ben-Zvi, 2003, p. 60-61)

Beyond such paradigmatic changes in the ways a teacher teach, the goals of teaching and learning include several dimensions and constructs such as interest, knowledge (cognition), emotion and motivation. (Hidi & Renninger, 2004; Shavelson et al. 2005) To support teachers in the acquisition of useful teaching abilities, it is necessary to reflect on the teacher needs. for this purpose the first teachers involved in the project, about twenty, completed a questionnaire developed by Jach Holbrook to identify the teacher needs. (Holbrook, Rannikmae & Valdmann, 2014) The results were discussed with teachers and it was decided that the content of the lectures and workshops dealt with the cooperative learning, to include a scenario to build a learning environment. To use concept maps in teaching to help students to be aware of their learning and to utilize problem solving methods. In all reported modules the teachers have used these methods, in agreement with their teaching styles.

After the formal course where teachers were acting as learners (in the last three years has been reduced to two or three afternoons), teachers have put into practice the new methods. Often teachers have found difficulties or wish to have explanations or confirmations. So they followed frequent visits to schools to help teachers in the reflection and in the acquisition of the necessary confidence. This has been and continues to be the most important task and time consuming. The extraordinarily positive aspect of this way of conducting the CDP is that it allowed you to develop a professional esteem and often a friendship, which helps the commitment to change. Very important acquisitions from teachers were the development of a great confidence in their potential and professional skills that helped the development of efficacy in the classroom.

An important message is to make small changes at a time. Please become familiar with the changes made, before making others. Students also need time to adapt to new things. It is fundamental that the teacher will always feel at ease. It is useful the suggestion of Felder and Brent (2016): to become them to more effective teacher does not require to throw out everything traditional. "We won't be telling you ... to abandon lecturing and make every class you teach an extravaganza of student activity. We will tell you to avoid making lecturing the only thing that happens in your class section." (p. 4)

The confidence, the sense of effectiveness in the classroom, the belief that they can have an impact on students' education helps to pique the interest of students and to convince them to "play" according the rules that we consider useful for their human and professional growth. The experiences that follow show that some teachers have acquired considerable skill and have come a long way in their professional development. Teachers have used existing modules to inspire themselves and develop new didactic modules or adapt (in a case) existing ones to their own didactic interests. Some original material developed by Italian teachers can be found at the URL: http://www.profiles.univpm.it/node/23?language=en (Accessed August 2016).

Kneaded, Cooked and Eaten

This module has been developed for and used in a third class and in two fifth classes of a primary school. This experience arises from the observation of how children are often passive consumers and unwitting victims of advertising messages. Through the analysis of a product widely used by all, the biscuits for breakfast, we tried to make them aware of what they eat.

With a questionnaire was asked to rank nine information on the packaging (When you pick up a pack of biscuits, which of the information on the packaging do you think is most important to read and take into account?): Product name; Weight; Ingredients list; Expiration date; Manufacturer's name; Location of the manufacturing plant; Nutritional table; Barcode; Price. Here is the ranking of sixteen students of the third class (Table 1):

Table 1. Classification of information according to the students in the third grade students.

Student	Product name	Weight	Ingredients list	Expiration date	Manufacturer's name	Location	Nutritional table	Barcode	Price
1	4	5	1	7	2	9	3	8	6
2	6	8	5	1	7	2	3	4	9
3	6	3	1	2	4	8	5	9	7
4	3	2	4	9	8	6	5	7	1
5	6	1	8	2	3	9	5	7	4
6	9	3	4	1	5	2	8	6	7
7	5	4	2	1	6	7	3	8	9
8	5	8	7	4	6	3	1	2	9
9	4	7	1	2	6	9	8	3	5
10	3	2	4	9	8	6	5	7	1
11	4	6	1	2	7	9	3	5	8
12	9	4	1	3	8	6	2	5	7
13	8	7	4	3	6	2	1	5	9
14	6	7	1	2	8	5	4	3	9
15	6	8	3	1	7	9	2	4	5
16	6	7	8	1	9	4	3	2	5

Classification of information according to the two teachers: 1. Ingredients list; 2. Price; 3. Weigh; 4. Nutritional table; 5. Expiration date; 6. Product name; 7. Manufacturer's name; 8. Barcode; 9. Location of the manufacturing plant. In Figure 1 are the choices of the students respect to the ingredients list.

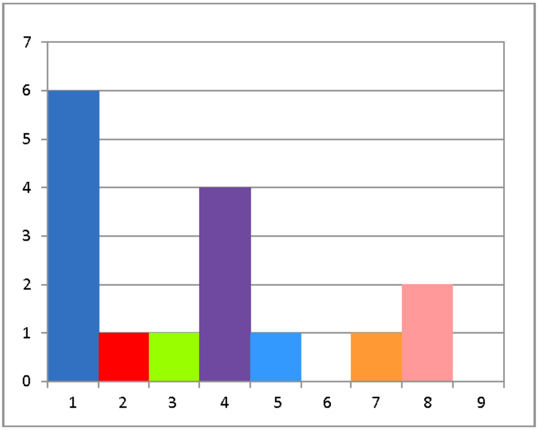

Figure 1. Number of students versus the ingredients list.

The module was planned also in detail with the help of three of the first teachers involved in the PROFILES project, experts in their school subject (Biology, Chemistry, and Mathematics) and in feeding.

This approach has been used in the belief that "do math" in primary school does not mean just run "operations" or "solve problems with arithmetic". In addition to this, it is important to initiate the students to other operations necessary to interpret the data and actual experience of everyday life. Mental operations such: represent, schematically and generalize that constitute the fundamental basis of mathematical skills. To ensure that pupils develop these skills requires a sea change in the way we work in the classroom: children should not be seated behind school desks but should discuss and debate between them, move to experiment, learn to reason, argue, and to speak about.

Another important goal of this experience are the 'vertical' interactions between children of different classes and age. The methodology is tutoring of the older children who lead the little ones exploring knowledge, working cooperative teams and when necessary, to help the younger solve problems. The purpose of this way of teaching is aimed to the development of all key citizenship skills. Students should learn how to learn, plan, communicate, collaborate and participate, act independently and responsibly, solving problems, creating connections and relationships, acquire and interpret information, to make the pupils future critical and responsible citizens. In this way, students are better prepared for the following schools and for higher education.

Figure 2. Students at work.

Visible learning and reasoning

For motivating students, all subjects in the curriculum were informed from this project, with the idea of making learning and reasoning visible. (Krechevsky et al., 2013) Now will be reported some examples related to mathematics.

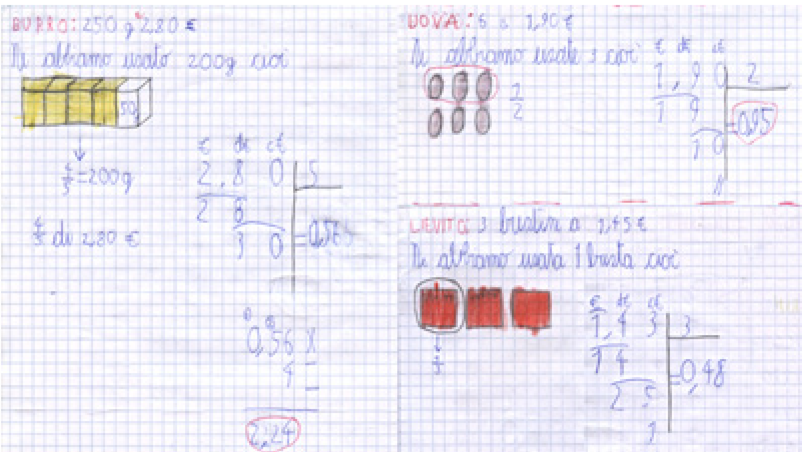

Figure 3. Representation of the problem: divisions and multiplication.

Figure 4. Students work on the module in cooperative teams.

Figure 5. Students in the supermarket discuss about type of flour, quality, and prices till a consensus has been reached. Back at school they prepared the dough to make cookies.

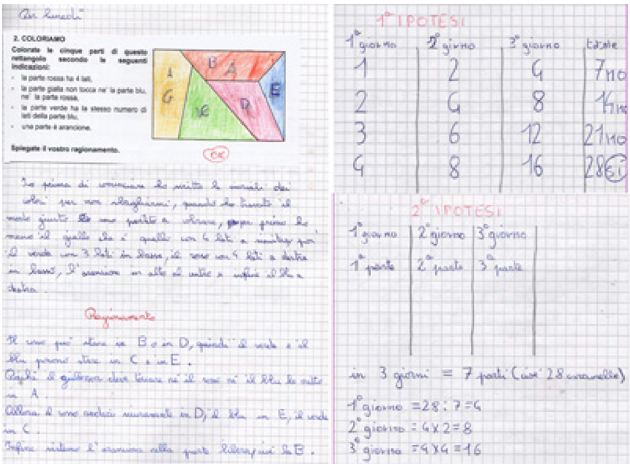

Figure 6. Students solved logic problems explaining their reasoning. In the right the original (and general) solution by a fifth grade children to the problem: For his birthday Carletto has received a gift box with 35 candies. Carletto is a very greedy baby and every day eats twice the previous day and in three days has eaten all. How many candies Carletto ate in each day? Explain how you found out.

Figure 7. A mind map to learn to read the label and the receipt. Bags for selling biscuits. Students have calculated the net weight and determined the selling price.

Chemistry and Biology: ... What a Pizza!!!

Two experienced high school teachers have developed two interesting modules: Chemistry ... What a Pizza!, and Biology ... What a Pizza!. (Online at: http://www.profiles.univpm.it/node/23) In Italian the phrase 'What a Pizza' has a double meaning: it is also referred to something very boring. In Italy, pizza is a ery popular food, especially among youth. This topic was chosen for its potential to interest and motivate students.

Students' motivation has been found to play an important role in their learning strategies, critical thinking, problem solving, conceptual change and learning. Significant studies had been conducted on the motivation concept (Dweck & Leggett, 1988; Ryan & Deci, 2000a). Brophy (2004, p. 249) defined motivation to learn as "a student's tendency to find academic activities meaningful and worthwhile and to try to get the intended learning benefits from them." The tendency to seek new challenges, to use and extend their skills, and to explore new areas as well as to learn is a component of our nature. "The construct of intrinsic motivation describes this natural inclination toward assimilation, mastery, spontaneous interest, and exploration that is so essential to cognitive and social development and that represents a principal source of enjoyment and vitality throughout life." (Deci & Ryan, 2000a, p. 70).

Richard Ryan and Edward Deci (2000b, p. 55) distinguish between different types of motivation: intrinsic and extrinsic motivation. "intrinsic motivation, which refers to doing something because it is inherently interesting or enjoyable, and extrinsic motivation, which refers to doing something because it leads to a separable outcome.” Despite its great importance and relevance, motivation is difficult to measure, because “to be motivated means to be moved to do something.” (Ryan & Deci, 2000b, p. 54) To measure an objective behaviour with a subjective questionnaire does not always yield reliable results.

If we increase the intrinsic motivation of students is more easy to overcoming students’ hostility towards science which often makes it difficult to learn complex concepts. Through the modules, the teachers wish to introduce the students to the study of biology and chemistry by means of daily life phenomena. In this context, science education is seen as ‘education through science’ (Holbrook & Rannikmae, 2007).

The aim of this project is to start from a known food to analyze, from a scientific point of view, the chemical transformations that take place during its preparation. Students are also encouraged to reflect on the parameters that can affect the final product. Furthermore, this activity promotes observation and reflection skills of students who are encouraged to deal with a practical problem (how to cook a good pizza) using an inquiry scientific methodology and an experimental approach.

This module has been used in a first class of high school by a teacher of chemistry, and in a second class of high school as a biology teacher. Student interest was raised problematizing and challenging their knowledge. Have you ever eaten a pizza that was not really perfect? Maybe it was overcooked or with large bubbles, or it was not crisp or too thin and not well leavened or had a crust with a light colour? Have you ever wondered what causes these defects? Do you know the basic ingredients of pizza? Have you ever prepared a pizza? Have you ever seen someone at home who prepares it? Do you know the “tricks” to make a good pizza? During the Christmas holidays the students were invited to seek information on the pizza, online, interviews with parents and grandmothers and to report the info in a concept map. back to school, each team discussed and designed a concept map on how to make pizza. A discussion of the class with the teacher to look for links with the program and consider the important questions on which students should reflect. What chemical reaction takes place during the leavening? What are the reagents and products of this reaction? Is it possible to identify them? What is the role of the leaven? By changing the amount of reagents, which results could be achieved? Changing working conditions (time, temperature, ...), which results could be achieved?

Through the answers to these questions, found by discussion/debate, web searches, interviews with experts and experimental activity, students will learn to isolate a chemical reaction in a complex phenomenon in order to correctly identify the reagents and the products and to understand the influence of some parameters on the reaction rate.

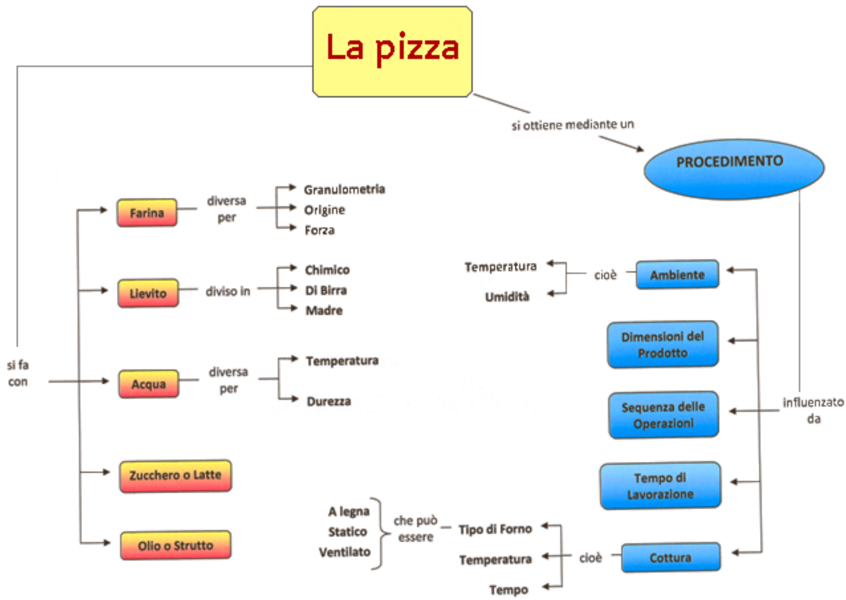

Figure 8. A concept map on how to make pizza and the variables that affect the process.

The overall curricular objectives of teachers are:

- To learn the concept of chemical transformation;
- To learn to balance a redox equation;
- To identify the transformation in a complex phenomenon;
- To learn the concept of fermentation;
- To identify the parameters that influence the transformation;
- To work as groups of students in safety in the laboratory;
- To carry out simple qualitative and quantitative laboratory tests.

Competences that students could acquire:

- To use the inquiry scientific method to study a phenomenon;
- To work as a cooperative groups, respecting all opinions;
- To encourage learning motivation through teamwork;
- “Learn to learn” for a meaningful learning;
- To prepare a good presentation in PowerPoint;
- To argue in public about various topics.

Figure 9. Biology and Chemistry students in the laboratory.

Several questions were posed to students to guide their research and their reasoning: All flours are the same? How are they different? What is the best? It is important the water temperature? Why? What is water hardness? How does hardness may affect the leavening? What are the functions of the salt? The salt is only used to give flavor? Search how it can affect the stability of the dough. In how many ways can the dough leaven? Do you know what is the sourdough? Do you know the brewer's yeast? Do you know why it is called so? Do you know other leavening agents (chemical yeast ...)? Do you know how they are formed? Why the salt should not be added in direct contact with the yeast previously dissolved in warm water? Why do you add a little olive oil or another fat? What is its function? Some people add a little milk or sugar: why? Students are asked to describe some experimental activities that Can demonstrate your hypothesis.

In the biology laboratory students have performed these experiments: 1. Identification of the gluten in the flour; 2. Reading of the labels of the leavening agents; 3. Observation of Saccharomyces with optical microscope. Instead chemistry students have determined: 1. The fermentation develops a gas: detection of CO_2 through testing with barite water; 2. The fermentation produces alcohol: detection by testing with potassium dichromate.

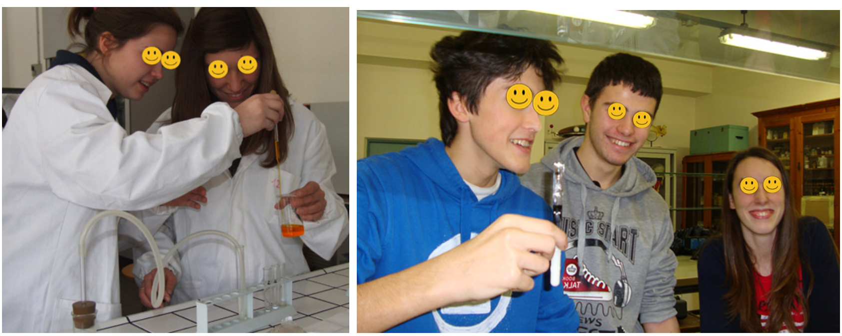

Figure 10. The smile and the students' involvement is a good indicator of their interest.

At the end of the work, each group was asked to submit a written report on their activities including the graphs for comparison of the data collected. All students have gone to a hotel management school where they presented their work: biology students have presented to students of chemistry and vice versa. On this occasion they have had the opportunity to ask questions of an expert in culinary technique and a cooking teacher. Also they proceed with the preparation and the tasting of the pizza.

Figure 11. Students during the presentations.

Figure 12. Students at work to prepare pizza.

Conclusions and implications

The European PROFILES project has had a very positive impact in Italy. The project has involved several hundreds of teachers in three different regions. Even though the project has ended a year ago, many teachers continue in their commitment and enthusiasm in teaching. The Italian site of the project shows a lot of the work that has been done. In the newsletter page has just been published the newsletter # 14. (http://www.profiles.univpm.it/node/24) Many good practices have been developed by teachers, as reported in the newsletters, and in the book "La buona scuola. Esperienze esemplari di insegnamento e apprendimento significativo. Exemplary Practices for Meaningful Teaching and Learning". (http://www.profiles.univpm.it/node/25) Two other experiences were presented at the 7th International Conference on Research in Didactics of the Sciences, DidSci 2016. (Book of Abstract, 2016)

One of the reasons that can explain this commitment can be the perception of the value of this new approach. Self-efficacy, or the belief that you have the personal skills and resources to meet the needs of a specific task is an important construct in the development of the professional development program. The effective individuals are motivated, persistent, directed to a purpose, resilient and able to find sensible solutions even under pressure. Another may be that teachers feel innovation as the fruit of their labor: it belongs to them. "One of the strongest conclusions to come out of decades of studies of the success and failure of a wide variety of curriculum innovations is that innovations succeed when teachers feel a sense of ownership of the innovation, or that it belongs to them and is not simply imposed on them." (Ogborn, 2002, p. 143)

With a questionnaire developed by the Department of Science Teaching of the Weizman Institute of Science, Israel, some ownership dimensions are measured, as the effectiveness in engaging students, the effectiveness in teaching strategies, teaching effectiveness through Inquiry and effectiveness compared to PROFILES practices. The questionnaire consisting of 20 items was sent by e-mail to about 80 teachers, among the most committed to the project. 34 teachers have completed and returned the questionnaire: the number is compared when you consider that it lacked privacy and certainly the results are understated compared to the real value. The questionnaire uses a Likert scale of nine points (1 lowest rating, 9 highest rating) and the results are all between 7.17 and 7.46.

Several reported pictures illustrate the enthusiasm of the students: this is related to teaching that stems from the new approach of teaching. As is reported in the newsletters, often students of these teachers are among the winners of regional and national scientific competitions. Often these students are among the best university students. A great satisfaction for teachers.

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Scientific research activity of students pre-service teachers of social sciences at university: aspects of understanding, interest, promoting and limiting factors

Introduction

Today, it is universally acknowledged, that in the contemporary world technological progress, innovations, knowledge economy are the basis of country economy and culture development. An obvious relation is noticed between country development level and knowledge economy part in general economics. Country future depends on science and technology rapid development, especially of those countries, the natural resources of which are not abundant and the main product is created owing to intellect. Rapid labour market demand change and knowledge becoming the essential success condition in the market economy grounded on competence, raise new requirements for its subject abilities as well, to obtain such knowledge which could allow not only to survive but also to defeat in a competitive fight. Today, the essential abilities in the knowledge society become research abilities, owing to which fundamental or applied knowledge is obtained. Therefore, today every society raises new education purposes, seeks to reconstruct its education system so, that it could control innovations influenced by globalisation and would prepare young generation to live in the globalised world and to act in the competition grounded market economy.

At this moment, it is especially important to support and encourage the gigantic European scientific research and innovation potential. European future depends on the investments to scientific research and innovation, therefore in the European strategy for smart, sustainable and inclusive growth “Europe 2020” (2010) a special attention is devoted to this. Programme “Horizon 2020” (2014) helps to seek this relating scientific research with innovations and concentrating attention to three main spheres: qualitative science, industry subject leadership and social character tasks. Its purpose is to ensure Europe to have world level science and technologies which would encourage economic growth. “Horizon 2020” is the biggest of all times EU science research and innovation programme. According to this programme it will be easier to transform perfect ideas from laboratory to market, so more breakthroughs, discoveries, inventions and nowhere else in the world offered products and services are expected.

Europe goes ahead in many science spheres. European Union performs a very important role in the world science and technology sector. It is an indisputable leader in many spheres. The ability to transform the knowledge into new-fashioned products, services and industry will determine Europe’s competitiveness and flourishing in a rapidly changing world. In EU the efforts are made to create common European scientific research space, in which the scientists could work in any ES country. It is sought to strengthen and encourage international collaboration, to support the most progressive scientific research. For this purpose, in 2007 European Commission established European scientific research Council (ERC – European Research Council). The purpose of ERC is to promote the scientific competence in Europe supporting and encouraging the best scientists (Scientific research and innovations. Opportunity development and life quality improvement. About European Union policy, 2014).

In the latest years, big changes took place in Lithuanian science system, by which it was tried to correspond to the existing European Union and Lithuanian problems. In Lithuanian progress strategy "Lithuania 2030" (2012) it has been foreseen to create a favourable science and research environment, ensuring Lithuanian attractiveness to the highest level scientists and researchers, to rally the best science and study potential of the country, to form suitable conditions for interdisciplinary scientific research and applied development. In Lithuanian science and innovation policy change guidelines (2016) it is asserted, that one of the most important preconditions of modern society progress and prosperity is competitive and congruous education, science and innovation system, related to the country's society and economy demands, encouraging the state's social progress and effectiveness in the international economic environment. Therefore, scientific research and experimental development is the axis of the country's innovation system.

Seeking to define the main study, scientific research and experimental (social, cultural) development trends, which would encourage harmonious human and society development, would strengthen the country's competitiveness, State study, scientific research and experimental (social, cultural) development, 2013–2020 development programme was prepared (2012). One of the aims of this programme is to guarantee consistent study and scientific research and experimental (social, cultural) development system functioning, to strengthen science and study institution leadership competences in the society and innovation management abilities.

The efforts are made in the country to geographically rally the available business potential apt to science and knowledge and to create integrated study, science and business centres (valleys) and to optimise Lithuanian science institution net. With the EU structural funds the biggest part of the country's scientific research and study infrastructure was renovated and open approach principle was implemented. Scientific research strategic management, talent fostering, guaranteeing the effective and stable financing, stronger integration to international space – these are big challenges for Lithuanian science system today. Not only statistic information presented in the review of Lithuanian science condition approves this, but also international expert recommendation retrospective (The review on Lithuanian science condition, 2015). A very important place in science occupies human potential, which assures consistent science system development. Over the latter decade, preparing PhD doctors quite a lot of changes took place in researcher career policy as well, however, up to now the questions concerning PhD's number remain unsolved. Only 2 % of all applying were accepted to doctoral studies in 2014-2015. In order to assure a sufficient science potential renewal, referring to international practice, there should be at least 5% of the applicants to doctoral studies. According to the experts', having participated in scientific activity comparative research statement, a lack of PhD doctors is felt in some spheres of science (The review on Lithuanian science condition, 2015). Therefore, it is very important to grow scientific potential.

World practice shows that studies at university are grounded on science, by them it is sought to prepare an educated man, compatible with the present world demands. Universities are not oriented only to concrete specialist preparation. In a wider context, a very important is university scientific activity, its level and society and economy demand conformity, contribution to the society and state development, preparation of educated, far-seeing people for active work. In the present world, not only to master knowledge becomes very important, but also to create and to participate in the society and world change himself. Especially highlighted is young people's interest in science: research, achievements, new possibilities. In order to know present world and to make competent decisions, one needs scientific knowledge and ability to control scientific world cognition method, science knowledge creation. Therefore, at universities more and more attention is paid to student scientific research work ability formation, critical thinking, creativity and productive self-expression education.

A number of documents are accepted in Lithuania, in which the unity of studies and science activity is accentuated, during the studies, students have a possibility to acquire and develop scientific research activity competence. The essential higher education document in Lithuania is Lithuanian Republic law on science and studies (2009). In Lithuanian Republic law on science and studies (2009) it is pointed out, that at university, university studies are carried out, scientific research, experimental (social, cultural) development are conducted. University goals defined in this law realise science activity and study unity:

- Carry out studies, providing the person with higher university education grounded on scientific research, conforming to the present cognition and technology level, higher education qualification, educate universally educated, ethically responsible, creative and enterprising personality;
- Congruously develop scientific cognition of all spheres, conduct high level scientific research and experimental (social, cultural) development, prepare scientists to collaborate with country and foreign partners in the scientific sphere;
- By scientific, educational, art and other cultural activities, collaborating with society and economy partners, encourage region and all country development.
- Educate society apt to education, science, art and culture, able to effectively use science and compete in high level technology, product and service market.

Tutor and student participation in scientific research and experimental (social, cultural) development, science worker participation in the study process, science knowledge and scientific work skill conveyance in the first and second level of the study programmes and in doctoral studies, ordered scientific research and experimental (social, cultural) development works for business carried out at universities, for non-state and public sector assure science activity and study unity at universities. Carrying out the studies of the second level is related with the results of science activity conducted at university.

The other important documents, regulating scientific research activity competence education in the study process are: The description of the study level (2011) and The description of Lithuanian qualifications framework (2010). The aim of the description of the study level (2011) is to describe the main peculiarities of separate study levels and qualitative differences, what abilities the person acquires after graduating the studies of one or another level. In this description it is pointed out, that after completion of the first stage studies, the person is able to conduct research: is able to gather and analyse the data, necessary for solving important scientific, professional activity problems, for cultural and artistic creation, using fundamental and applied scientific research achievements and methods. Lithuanian qualifications framework description (2010) is prepared seeking to classify the established in Lithuanian Republic qualifications. Scientific literacy is also accentuated in it and it is pointed out, that level VI qualification (bachelor) is meant for a complicated activity, distinguishing itself by the task and their content diversity, the performance of the activity requires to apply wide theoretical knowledge, grounded on new fundamental and applied research results.

The documents also important in the study process, regulating scientific research competence education are: Education study field descriptor (2015) and The description of professional competence of a teacher (2007). The abilities ascribed to the first study level (bachelor) for carrying out a research are indicated in these descriptions:

• Apply various education and training science knowledge, the learners' achievement research results and specialised information technologies, performing the research, analysing and sorting out the findings, visualising and presenting the results;

• Find and analyse education and training scientific and information literature, apply modern information accumulation, analysis and systematisation ways;

• Identify education and training research problem, formulate research aim, tasks and hypotheses;

• Prepare research work methodics – select research strategy and methods;

• Gather, process, analyse, generalise and interpret research results, discuss about them, formulate research conclusions and recommendations;

• Solve education and training problems, following the research, including the learners' achievement research, results.

University as the most important higher education institution, developing scientific cognition of various spheres, creating innovations, carrying out high level scientific research and experimental development trends, preparing scientists and carrying out the highest level university studies grounded on scientific research, has all possibilities to provide education and special (also including scientific research) competences, conforming to the present and future society and economy demands.

Scientific research activity problematic is actual not only in Lithuania. Over the latter several years, quite a lot of research were performed in various countries. It is especially accentuated, that it should be as early as possible initiative already at primary school (Bolmont, 2007). On the other hand, social science study programme students are less prone to participate in SRA, besides, the character and specifics of the studies themselves presuppose a much poorer relation with SRA as compared to natural science study programme students. So, the question remains the same, how to get students involved, how to enable them, and motivate them to learn more and to learn it better (Neuby, 2010).

Therefore, the research object is scientific research activity conducted by the students pre-service teachers of social sciences at the university. Research aim is to analyse how students understand SRA, what is their interest in such activity, and what are such activity promoting / limiting factors.

Research Methodology

General Characteristics of Research

The research was carried out between January and February 2016, i.e. at the beginning of the second term of studies. The research is based on the attitude that student opinion and evaluated research play an important role due to the fact, that they allow establishing urgent problems and clarifying the already known issues. Referring to the analysis of the proposals made by the students, the ways of finding a solution to the problem and the evaluation of possible consequences should be suggested. Investigation into opinions is an effective means seeking to initiate changes, in this case, to improve scientific research activity of the students' pre-service teachers of sciences. This examination is based on the previously conducted expert research (Lamanauskas, Augienė, 2014; Lamanauskas, Augienė, 2015).

Research Instrument

The questionnaire (answer sheet) prepared by the authors was used in the research and included 10 major open questions/tasks.

- How do you understand scientific research activity of the students at university? Comment

• Are you interested in scientific research activity? Comment

• What do you think mostly hinders the students to involve (participate) in scientific research activity at university?

• What do you think mostly encourages/motivates students to involve (participate) in scientific research activity at university?

• What importance do you think scientific research activity has for teacher's profession?

• Do you think the study process at university is favourable and promotes to choose scientist (researcher's) career in future?

• Please comment how scientific research activity contributes to your professional readiness?

• Comment about your personal preparation to take part in scientific research activity?

• Would you like to have a researcher (scientist) job in future?

• How would you recommend to improve study process, seeking to strengthen/ make more effective students' scientific research activity?

The questions cover the basic parameters of scientific research activity such as awareness, interest, interfering and motivating factors, importance to the teacher's profession, a personal level of training, recommendations, etc. The results, obtained on the basis of 1-4 questions, are presented in this article.

Research Sample

The fourth year BA students pre-service teachers of sciences from two Lithuanian universities – Siauliai University (59 students) and Lithuanian University of Educational Sciences (31 students) participated in the research. Totally, 90 female students took part in the research. The above mentioned universities are the main institutions educating social science teachers in Lithuania. According to the study programmes, the respondents were divided as follows: pre-school education pedagogy (11), primary education pedagogy (29), family pedagogy and children rights protection (22), and logopedy (28).

For the formation of sample, non - probability purposive research group formation method was chosen, when the people included into a research group are the most typical in respect to the researched quality. Referring to Morse (1994), the sample of 30-50 participants is suitable for such kind of research. On the other hand, basically, there are no strict and specific rules forming the sample for qualitative research. Qualitative sample size may best be determined by the time allotted, resources available, and study objectives (Patton, 1990). Forming the mentioned sample, it was taken into consideration that: a) the respondents are the fourth (final) year bachelor's degree students; the respondents have performed all pedagogical internships, foreseen in the study plan. The attitude is hold, that such sample is sufficiently representative in a qualitative research.

Data Analysis

Research data were expressed in writing. The obtained respondents' answers were coded. The most frequently repeating semantic units were grouped until the initial groups called sub-categories appeared. In the second stage the sub-categories were combined into categories. The qualitative research data were processed using content analysis, when in the informative array essential characteristics are distinguished. The obtained verbal data array, referring to conventional content analysis methods, was analysed in three stages:

- multiple answer reading;
- semantically related answers and "key" words are sought;
- semantic unit interpretations.

In order to guarantee data analysis reliability, semantic unit distinction and later on grouping was carried out independently by three researchers. In the later stage, the researchers were looking for a consensus due to sub-category attaching to categories. The co-ordination degree was higher than 80%.

Research Results

Having analysed the researchers' expressed opinions about student scientific research activity at university, the corresponding categories were distinguished, defining the understanding of the latter (table 1).

University studies consider student scientific research activity of great importance and seek, that the students acquire scientific research competence and are able to systematically and purposefully analyse reality objects, applying scientific devices and methods, are able to acquire new knowledge about research objects, about reconstruction of these objects, using various technologies. Therefore, it is completely understandable, that students relate scientific research activity at university with their studies. The first category obviously demonstrates that the biggest part of students (52.7%) understand scientific research activity at university as a compulsory study process component, where final work performance (34.7%), scientific source studying (11.2%) and study task performance (6.8%) occupy the most important place. In the study process, the students are doing scientific research works very actively, preparing paper and bachelor works, therefore even 20.0% of students relate scientific research activity with the accomplishment of these tasks.

The second category "Active work" reveals, that a big part of students (36.2%) understand scientific research activity as active work, in which the students carry out and present research (31.05%). One can think, that scientific research activity for these students is more than part of a study process, because they point out, that they do research with the other students, with the tutors, participate in seminars, conferences and this activity is interesting for them.

Table 1. The understanding of student scientific research activity at university

Categories	N/%	Subcategories	N/%	Statements	N/%
Compulsory Study process component	60/52.7	Final work performance	39/34.7	Course paper and bachelor thesis preparation	22/20.0
				Activity covering various student written works	8/7.0
				Such activity is a constituent part of bachelor thesis	3/2.6
				Specific information gathering, paperwork writing	3/2.6
				Research of a topic for bachelor or master thesis	2/1.7
				A compulsory activity finishing the studies	1/0.8
		Studying of scientific information sources	13/11.2	Analysis, studying of scientific literature (sources)	10/8.6
				Various field research, referring to scientific sources	3/2.6
		Study task performance	8/6.8	Report preparation, presentation in the lectures	3/2.6
				Activity related to studies	3/2.6
				Various problem investigation during practical activities	1/0.8
				This is the way to check student's abilities performing the research	1/0.8
Active work	42/36.2	Research performance and presentation	35/30.2	Various research performance	18/15.6
				Scientific research conducted by students working alone or with the other students or with the tutors	8/7.0
				These are various surveys, filling in questionnaires, data processing, generalisation	5/4.3
				This is participation in various events, seminars, conferences	2/1.7
				The chosen problem which is researched	1/0.8
				Various educational research carried out at university	1/0.8
		Interesting activity	7/6.0	This is a constant student activity	4/3.5
				Activity when a student can observe and analyse what is interesting for him and useful	2/1.7
				This activity is only for active and interested students	1/0.8
Professional improvement (personal/professional desire to improve, new activity perspectives, personal activity) encouraging students to be involved in scientific research activities.)	11/11.1	Knowledge acquisition	7/6.0	This is an activity, helping to acquire more knowledge, to improve	6/5.2
				This is new knowledge, discovery search	1/0.8
		Studying of the chosen field	4/5.1	This is students' extra academic work in a particular chosen field	3/2.5
				Such activity is learning for future	3/2.5

Note: Totally, 115 semantic answers were distinguished.

The third category "Professional improvement" illustrates, that not a big part of students (9.8%) identify scientific research activity with professional improvement and point out, that scientific research activity is acquisition of knowledge (6.2%), studying of a chosen field (3.5%).

Having analysed the respondents' expressed opinions about students' interest in scientific research activity at university, the corresponding categories were distinguished, defining the latter interest in such an activity (table 2).

Table 2. Students' interest in scientific research activity

Categories	N/%	Subcategories	N/%	Statements	N/%
Obligatory /pragmatic interest	50/44.5	Task performance	28/24.4	Interested as much as the studies (study process) require	12/10.0
				Interested when it is necessary	5/4.5
				Interested only when it is related with practice	5/4.5
				Interested as much as it is necessary for lectures or other study works	4/3.6
				Sometimes interested	2/1.8
		Final work preparation	22/20.1	Interested, because it is necessary to write various written works	8/7.3
				Interested, as much as it is related with course paper writing	7/6.4
				Interested, as much as it is related with bachelor thesis preparation	7/6.4
Personal/ inner interest	34/30.8	Interesting activity	20/18.1	Basically, interested	8/7.3
				It is interesting for me, therefore, I'm trying to participate in such an activity	5/4.5
				Interested, because I'm doing scientific practice	4/3.6
				Interested, if the research, which I have to perform, is interesting and actual for me	2/1.8
				Interested, because I like being involved in scientific research work	1/0.9
		Scientific source studying	14/12.7	Interested, because I'm reading various articles, other sources	10/9.1
				Sometimes I'm analysing the research of other people, when I'm searching for information in the field that interests me	2/1.8
				Interested, because I'm trying to look through new publications in the internet	1/0.9
				Sometimes I read scientific journals	1/0.9
Being uninterested in scientific research activity	26/24.7	Uninteresting activity	21/20.2	Uninterested	14/13.8
				Does not interest much, interest is minimal	7/6.4
		Too much complicated activity	4/3.6	Uninterested, because this is a rather complicated activity	4/3.6
		Lack of information	1/0.9	Uninterested, because I even don't know what research are being performed at university, nobody involves	1/0.9

Note: Totally, 110 semantic answers were distinguished.

As it was expected, the biggest weight has the category “Obligatory/pragmatic interest”. It is obviously seen, that the biggest part of students (44.5%) are interested in scientific research activity only as much, as the study process requires: task performance (24.4%), final work preparation (20.1%).

The second category “Personal/inner interest” illustrates, that for almost one third of the students (30.8%) scientific research activity is an interesting activity, encouraging to be interested in scientific literature.

The third category “Being not interested in scientific research activity shows, that for even 20.2% of students such activity is uninteresting, for 3.6% of students – it is too complicated, 0.9% of students – lack information.

The research results, presented in table 1 and in table 2, obviously show the conformity between students’ understanding what is scientific research activity at university and their interest in this activity. It is believed, that if scientific research activity is understood as a compulsory study process component, then interest in scientific research activity is also obligatory/pragmatic i.e. as much as tasks and final works performed in the study process require. It is also believed, that if scientific research activity is understood as active work, then inner/personal interest encourages interest in scientific research activity as well. Students’ expressed ideas allow making an assumption that the latter are interested in scientific research activity and actively participate in it not only in the study process carrying out the tasks.

Having analysed the factors, limiting students involve in scientific research activity, the corresponding categories were distinguished (table 3).

It is obvious, that the biggest weight has the category “Study process and content gaps (45.8%). The majority of factors, hindering the students to participate in scientific research activity, are related with not having knowledge about scientific research activity (24.2%), the students also point out a number of factors, which are related with the tutors’ reluctance to collaborate with students, performing various research (13.8%). Some students indicated lack of scientific research activity tasks (4.8%) in the study process and scientific research activity non conformity with the study process (3.0%).

The second category “Lack of motivation (38.6%) reveals students’ lack of interest in scientific research activity. This category covers such factor groups: uninteresting activity (33.2%), lack of self-confidence (5.4%).

The third category is “Big student occupation” (15.6%). Most often time shortage is indicated here (9.6%), part of students work (3.0%), the others emphasize a big activity workload (3.0%).

Having analysed the factors, promoting students to involve in scientific research activity, the corresponding categories were distinguished (table 4).

Table 3. Factors, limiting students to involve (participate) in scientific research activity at university.

Categories	N/%	Subcategories	N/%	Statements	N/%
Study process and content gaps	75/45.8	Not having knowledge about scientific research activity	39/24.2	Just not knowing what it is and how to start such an activity, lack of information	20/12.8
				Lack of knowledge, especially about SRA	10/6.0
				The complexity of an activity	3/1.8
				Lack of experience	3/1.8
				Unpopularity of such an activity	3/1.8
		The tutors' reluctance to collaborate with students	23/13.8	The tutors' disinterest, discouragement from the tutors' side	10/6.0
				Lack of collaboration between students and tutors	8/4.8
				Lack of interest	4/2.4
				Lack of organisation	1/0.6
		Lack of scientific research activity tasks	8/4.8	Few research activities during the studies	6/3.6
				Lack of tasks, promoting to involve in scientific research activity	2/1.2
		Nonconformity with the study process	5/3.0	Not properly organised studies, subject (lecture) layout	4/2.4
				Nonconformity with lectures	1/0.6
Lack of motivation	64/38.6	Uninteresting activity	55/33.2	Reluctance to be occupied with such an activity	14/8.5
				Lack of motivation	12/7.3
				Other interests, willingness to take up another activity	8/4.8
				Unwillingness to learn additionally	6/3.6
				Need (necessity) question	6/3.6
				Lack of initiative	5/3.0
				Indifference, passiveness	4/2.4
		Lack of self-confidence	9/5.4	Student shyness, certain fear to involve in such an activity	7/4.2
				Student status	2/1.2
Big student occupation	26/15.6	Time shortage	16/9.6	Time shortage	16/9.6
		Work	5/3.0	Extra and/or direct work	5/3.0
		Activity workload	5/3.0	Too big activity workload	3/1.8
				Big occupation	2/1.2

Note: Totally, 165 semantic answers were distinguished.

Table 4. Factors, promoting students to involve (participate) in scientific research activity at university.

Categories	N/%	Subcategories	N/%	Statements	N/%
Study process environment	77/57.1	Collaborative environment	31/22.9	Tutor encouragement, willingness to involve students	22/16.3
				Common work with authoritative tutors	6/4.4
				Proper information presentation about this activity	3/2.2
		Relation of the activity with the study process	21/15.6	Necessity to prepare course paper and/or bachelor thesis	10/7.4
				Intention to further continue studies in the postgraduate studies	5/3.7
				Properly presented and adequate tasks during the studies	4/3.0
				Closer relation of such activity with the studies	2/1.5
		Evaluation environment	14/10.4	Extra evaluation by grades (encouragement by evaluation)	8/6.0
				Such activity evaluation, understanding the essence	3/2.2
				Wish to be evaluated	3/2.2
		Actual scientific research areas	8/6.0	The interest of such an activity, getting interested in	4/3.0
				New, interesting research areas, the actuality of problems	4/3.0
		Organisational environment	3/2.2	Positive environment	2/1.5
				Student societies, clubs, communities	1/0.7
Professional interest	49/36.3	Personal / professional improvement	26/19.2	Possibility to acquire new knowledge and/or to deepen your self-knowledge	15/11.0
				Wish to improve	8/6.0
				Curiosity, wish to find out more	3/2.2
		New activity prospects	15/11.2	New experience, ambition to acquire new experience	8/6.0
				Actual problems, which the students encounter	5/3.7
				Possibility to try oneself in such an activity	2/1.5
		Personal activeness	8/5.9	Student activeness	5/3.7
				Personal motivation	2/1.5
				Student hobby	1/0.7
Pragmatic interest	9/6.6	Materialistic interest	6/4.4	Possibility to get a bigger grant	3/2.2
				Money encouragements	2/1.5
				Possibility to get extra funding	1/0.7
		Activity usefulness	3/2.2	Usefulness for the student, the use of such activity in general	3/2.2

Note: Totally 135 semantic answers were distinguished.

The first category “Study process environment” (57.1%) shows the real situation, which encourages students to involve in scientific research activity. The majority of students (22.9%) indicated, that the created collaborative environment encourages them to involve in scientific research activity, the relation of this activity with the study process (15.6%), proper, encouraging evaluation system (10.4%), actual scientific research fields (6.0%) and organisational environment (2.2 %)

The second category "Professional interest" (36.3%) shows, that students participate in scientific research activity seeking to properly prepare for their professional activity .Here, the students show, that the factors related with their personal/professional improvement (19.2%) with the new activity prospects (11.2%) and personal activeness (5.9%) encourage them to involve in scientific research activity.

The third category "Pragmatic interest" (6.6%) shows, that only a small part of students involve in scientific research activity encouraged by materialistic values.

Conclusions

During the research it has been stated, that the biggest part of students understand scientific research activity as a compulsory study process component and relate this activity with final work, study task completion, studying of scientific literature. More than one third of students understand scientific research activity as active work, pointing out, that it is an interesting activity for them, related with the conducting and presenting the research. A small part of students understand scientific research activity as professional improvement.

Analysing student interest in scientific research activity it has been stated, that the interest in this activity of the bigger part of students is obligatory/pragmatic i.e. students are interested in scientific research activity only as much as it is required in the study process, various tasks and final study works are performed. The interest of the third of students in scientific research activity one can relate with personal/inner interest, because these students pointed out, that this activity is interesting for them, they perform scientific practice, actively participate in scientific research. Yet the fourth part of students are not interested in scientific research activity, defining, that this activity is not interesting for them, too complicated, there is lack of information.

Analysing students' indicated factors, which hinder them to involve (participate) in scientific research activity, it was revealed, that the majority of students relate this with the study process and content gaps. Their expressed ideas allow asserting, that students lack knowledge about scientific research activity, there is lack of tutors' collaboration with students, some students think, that there is not enough scientific research activity requiring tasks in the study process. The ideas expressed of more than a third of students allow asserting, that the main factor, hindering these students to participate in scientific research activity is lack of motivation. The latter indicate that this activity is not interesting for them, they have no need for such an activity, they have other interests, they do not want to put in extra effort and so on. Only a small part of students identify big occupation as the main hindrance to involve in scientific research activity.

Analysing the factors, which promote the students to involve (participate) in scientific research activity, one can state, that more than half of the students relate this with study process environment, accentuating favourable collaboration, evaluation, organisational study process environment, actual scientific research spheres. Professional interest: personal/professional desire to improve, new activity perspectives, personal activity encourage the students to involve in scientific research activity.

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Teaching Physics to the students using problem solving scheme

Introduction

The focus of many academic studies in Physics is concentrated in problem solving, like being one of the main ways of conceptual learning. To serve to this purpose is even the preliminary evaluation, weighing or "measurement " as a requisite to problem solving.

This "measurement" is constrained by the principle:

Since the main purpose of Physics is learning about the truth of the world around us, the conceptual understanding needs a preliminary information related to the concepts that people have about the world around them and referred to these needs, the way on how to bring these concepts in accordance with the Physics lines (Anderson, 1990; Domelen).

Convincing reasons, related to the prior necessity of "measurement" for finding new methods have been given for instance from the results of the American Institute of Physics study in 1994. According to them different individuals, from all the areas, educational and non-educational and with different educational level, were asked to put in order different abilities required in their job lines. Among the interpersonal, computer, managerial abilities etc. was even the cognitive ability of physics concepts and the importance of Physics problem solving. Once the questionnaire was over all the groups, almost to the extent of 100% ranked the Physics solving problem as an "often used" ability. These results shows that the necessity of enabling students in problem solving will always remain at the first place and it strongly suggests the expanding research over the methods needed in increasing the abilities for their solution.

Methods

The general solving strategy

Solving a Physics problem usually breaks down in three stages

1. Design a strategy.
2. Execute that strategy.
3. Check the resulting answer.

This document treats each of these three elements in turn, and concludes with a summary.

Design a strategy.

Look before you leap

If you start your work the execution stage immediately, you will likely write down a lot of correct statements that do not lead to an answer. Instead, think about the problem on an overview level. What sort of conceptual tools will you need to solve the problem? What path will you take to the solution, and in what direction should you start off? Concretely, it often helps to classify your problem by its method of solution.

Where are you now, and where do you want to go?

The second step needs to be clear about what the goals are. For this reason is very effective to get an overall sense of the problem, nothing beats summarizing the whole situation with a diagram. The diagram will organize your work, state the starting point and suggest ways to proceed.

Keep the goal in sight

"It should be found to find ***Z***. If I knew ***Y*** I could find ***Z***. If I knew ***X*** I could find ***Y*** . . . " and so forth. Is that part of strategy that puts in focus the objective and stimulates finding the way toward its achievement. This is called the strategy of intermediate variables finding . It is useful to make a list of the information given and the goal to be discovered.

Ineffective strategy

Have you ever paged through your book looking for a special formula that will give you the answer. This strategy is non-effective. Physics teachers do not assign problems in order to torture innocent young minds but on the other hand the do not give exercises or problems that are solved by a single formula. They assign problems in order to force you into active, intimate involvement with the concepts and tools of physics. Rarely is such involvement provided by plugging numbers into a single equation, hence rarely will you be assigned a problem that yields to this attack. The most effective way to find that formula is by thinking about the physical principles and phenomenas involved, not from a magic formula.

Make the problem more specific

This step means establishing analogy with other problems previously solved. This also requires tests with known numerical values in the chosen equation, to understand if it is the right one or if the solving way is correct.

Execution of the strategy (Tactics)

Work with symbols / parameters

Depending on the problem statement, the final answer might be an equation or a number. In either case, however, it's usually useful to work the problem with symbols and plug in numbers, if requested, only at the very end. There are three reasons for this: First, it's easier to perform algebraic manipulations on a symbol like "m" than on a value like "2.59 kg". Second, it often happens that intermediate quantities cancel out in the final result. Most important, expressing the result as an equation enables you to examine and understand it in a way that a number alone does not permit.

Define symbols

If a problem involves a helium atom colliding with a gold atom, then define mh as the mass of the helium atom and mg as the mass of the gold atom. If you instead pick the symbols m_1 and $\boldsymbol{m_2}$, you stand a good chance of mixing up the symbols and their meanings as you solve the problem and as a consequence to the parameters related to them(ex velocity) and eventually the confusion in problem argumentation.

Symbols packets

We are referred to a simple case in the Physics of electricity, exactly to the force of Coulomb

$F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 \cdot q_2}{r^2}$ This equation consists of a number of symbols, listed in a certain way and has a certain view,that can be considered a package. This package has an unforgetable form that eases the physics problem solving and interpretation. If we give another semblance to this package by changing the place of the symbols like for example

$F = q_1 \cdot \dfrac{1}{\varepsilon_0 4} \cdot \dfrac{q_2}{r^2 \pi}$, , then its form seems unknown and the Coulomb force has lost the integrity.

Dimensions/symbols units/variables

If a problem has given the numerical values of the parameters, expressed in different dimensions (for ex. the force in Kg or Newton) the all the forces should be transformed in Newton. If all the forces are given in Kg, even though this unit is not the unit of force in SI, can remain like that if the problem ends in here. But if there is another variable, that is included with the force in the equation, then should be done the appropriate turning of the dimensions, referred to those of the other variable. if it happens that all the lengths are given in inches, as this unit is not used in our country, then in order for the result to be interpreted it is necessary to be converted into meters or centimeters of the given size in inches. Despite this as a concrete solution is recommended the conversion of all the variable conversion in SI; This does not only make possible the argumentation of the numeric value found but through dimensions' size of the final result is verified the accuracy of the respective equation.

Solution

Approximations, laws / equations, reference systems, mathematical aspect (derivates, integrals, trigonometric functions etc.) detection of the unknown in - between, detection of the final unknown are part of the problem solving.

Check the resulting answer

Answer confrontation

Checking your answer does not mean comparing it to the answer in the back of the book. This is only the formal step. It means finding the characteristics of your answer and comparing them to the characteristics that you expect. In either case, checking your answer is not just good problem solving practice that helps you gain points on problem assignments and on exams. The checking stage builds familiarity with the content of physics and the character of problem solutions, and hence develops your intuition to make solving other problems and learning more physics easier (Styer, 1998).

Dimensional analysis

If the solution encountered in a variable form (with symbols) is accurate then all the variables dimensions on the right of the equation should be dimensionally consistent to the left part.

Numerical reasonableness

If the mass of an electron is in mg, the solution is not correct. What about the velocity in a plane is that correct to say 1m/s for a flying plane? It is hard speaking about reasonableness if it is expressed in meters/second. The above mentioned velocity is 3.6 km/hour which is not correct.

Algebraically possible

If the solution found takes the square root of negative number, that is algebraically impossible.

Functionally reasonable

If in a free vertical launch up the velocity of a body is increased, this is a non common sense solution.

Special cases

If you solve a problem regarding two objects with two different masses, that interact ,then the required solution takes in cosideration if their masses are equal, which makes it part of a special case.

Specify directions and vectors

"The distance is 5.72 m" is not an answer because it should be shown the direction and the vector. If it is requred the demonstartion of vectors, it is impossible as long as the velocity direction is unknown.

Specific strategy

"Every time that there is a huge gap between where we are and where we want to be and the solving way is still unclear, we are in front of a problem" (Hayes, 1989). Exercise solving is an in-between phase which consolidates the knowledge toward problem solving.

All researcher agree that physics problem solving requires:

A) Implementation of a theory acquired beforehand (Heller, Keith & Anderson, 1992; Heller & Hollabaugh, 1992)

B) Analytical skills in analyzing and solving a problem.

Quite a few researchers complain about the fact that students solve problems mechanically (Styer, 2002, Bolton, 1997). For this reason some authors argue that the most effective way of acquiring physics is the independent solving way of not very complicated problems. Different researches in physics teaching have offered specific useful strategies on problem solving. Strategy design or a solving scheme is a method based on rules that help students to organize their knowledge in an effective way and makes possible the solving of given problems. The simplest way in accomplishing a strategy design can be done by organizing a list that defines a series of instructions for solving a group of problems which is demonstrated as a diagram. The diagram is the presentation of the information that serves to schematic visualization of the problem and can be used like a legend or map. Drawing an accurate diagram for the problem is very important because it is believed that it roughly represent 80% of success solving. (Apalkov, 2007)

On behalf of what was mentioned above, we designed a Strategy, that is a problem solving scheme. It seems like computer links, with "labyrinths" and "obstacles". Both are like a map, help students to understand the way that should be followed and how to choose it, to arrive at the right destination. This is consistent to the fact that Strategy design does not give automatically a solution to the problem but shows the way toward it.

Summarized detailed scheme is given below:

a. Introduction of problem

- Cognition of problem
- Designation of the field/s of Physics where the problem is mixed in
- Physical description of phenomena
- What is known, what is required
- Illustration in diagrams and figures
- Highlight the explicit and/or implicit conditions/ hypothesis

b. Solving the problem

First phase: physical aspect

- Requirements.
- Suppositions, referred to explicit and implicit conditions
- Parameters/variables already known
- Equation, which obviously contains the required parameter.
- Successive equations, with intermediate unknown data shown in previous equations. (we stop writing them in case there are no more unknown intermediate data)
- Verification of the total number of written equations, which should be n+1, where the n is the number of intermediate variables.

c. Comment of theoretical result

- Discussions for a new and deep physical interpretation
- Discussions of special matters

d. Comment of quantitative results after the numeric replacement of variables

- Solution with symbols is a substitute for Numeric data.
- Discussion of numeric value

Results

We used the scheme above for solving problems with one group of students and compared their results with a group where never used the scheme. We have compared the results achieved from two groups for the hole semester. Students belong to branch Mathematic-Informatics.

All the results achieved from two groups of students are summarized below:

Table 1. A summary table of the results of students where we applied the problem-solving scheme

Student	High school average grade	Theme in group points (max 10 points)	Partial exam (max 10 points)	Activation while in class, homework in points (max 10 points)	Total points of interim results (max 30 points)	Final exam (max 70 points)	Grade[1]
Student 1	8.4	6	5	8	19	35	6
Student 2	8.89	3	3	7	13	30	5
Student 3	9.18	7	9	9	25	56	9
Student 4	9.3	9	6	4	19	42	7
Student 5	9.89	6	6	10	22	40	7
Student 6	9.7	8	6	10	24	40	7
Student 7	9.76	7	7	6	20	43	7
Student 8	8.9	4	3	7	14	48	7
Student 9	8.9	2	4	7	13	13	4
Student 10	8.78	8	5	9	22	40	7
Student 11	7.8	4	4	7	15	26	5
Student 12	9.85	8	8	9	25	46	8
Student 13	7.76	5	5	8	18	24	5
Student 14	6	1	1	5	7	6	4
Student 15	8.9	5	3	8	16	25	5
Student 16	8.6	3	3	7	13	15	4
Student 17	6.4	1	3	7	11	14	4
Student 18	8.7	4	5	6	16	45	7
Student 19	8.98	6	5	7	18	33	6
Student 20	9.7	6	4	8	18	35	6
Student 21	9.98	8	8	9	25	46	8
Student 22	7	1	2	6	9	4	4
Student 23	9.84	2	4	7	13	29	5
Student 24	6.6	1	1	6	8	3	4
Student 25	8.89	4	4	7	15	26	5
Student 26	7.6	4	4	7	15	26	5
Student 27	9.89	7	7	9	23	50	8
Student 28	9.61	10	9	10	29	65	10
Student 29	9.31	5	5	8	18	33	6

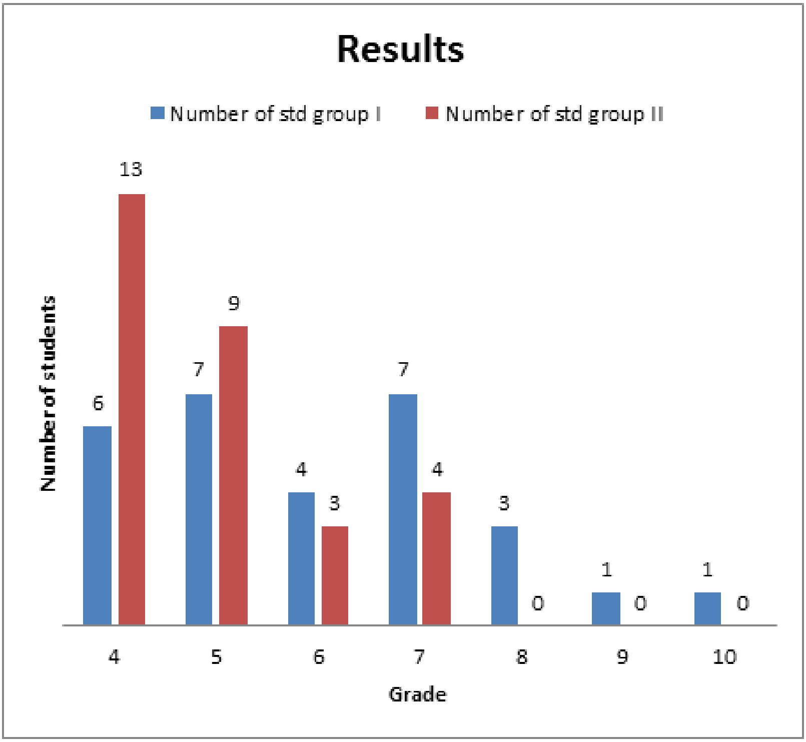
[1] [1]Based on theregulations of the University of Korce, the studenst can obtain a maximum of 30 points during the semseter (these are called interim result points) Conversion of these points into grades is shown below:

Points (Final exam + interim results)	Grade
0 - 39	Non- passing grade 4
40 - 50	5
51 - 60	6
61 - 70	7
....	....
[illegible]	[illegible]

Table 2. A summary table of the results of students where we didn't applied the problem-solving scheme

Student	High school average grade	Theme in group points (max 10 points)	Partial exam (max 10 points)	Activation while in class, homework in points (max 10 points)	Total points of interim results (max 30 points)	Final exam (max 70 points)	Grade
Student 1	7.5	3	2	5	10	8	4
Student 2	9.3	5	5	8	18	33	6
Student 3	8.5	3	6	6	15	27	5
Student 4	9.4	6	6	10	22	40	7
Student 5	8.5	5	5	10	19	33	6
Student 6	7.5	3	4	7	14	27	5
Student 7	7.2	2	2	6	10	8	4
Student 8	7.3	1	1	6	8	5	4
Student 9	6.7	2	3	7	12	8	4
Stud.10	7.8	3	4	7	14	27	5
Stud. 11	8.5	6	7	10	23	40	7
Stud. 12	6.6	2	1	8	11	8	4
Stud.13	8.4	5	4	8	17	24	5
Stud.14	8.3	3	4	7	14	27	5
Stud.15	7.8	2	3	6	11	12	4
Stud.16	8.5	5	4	6	15	26	5
Stud. 17	8.68	3	4	7	14	38	6
Stud. 18	7.5	4	3	5	12	8	4
Stud.19	7.5	1	2	7	10	7	4
Stud.20	7.5	2	1	7	10	10	4
Stud.21	8.4	2	3	8	13	6	4
Stud.22	7	1	1	8	10	4	4
Stud.23	8.85	3	3	7	13	28	5
Stud. 24	8.15	2	2	8	12	10	4
Stud. 25	8.4	3	1	7	11	13	4
Stud. 26	9.35	6	7	8	21	41	7
Stud. 27	8.89	5	6	8	19	44	7
Stud. 28	8.79	4	5	8	17	25	5
Stud. 29	9	4	6	8	18	24	5

If we carefully examine the results of all the students, we realize that the results of Group 1 (as shows Table 1) are much higher than those of Group 2 (as shows Table 2). Graphically illustrated the results are shows below:



Conclusions

Solving problems in Physics is easier if we use a scheme to solve them.

Students have the opportunity to organize their knowledge in physics if we use the scheme specified above.

The results of groups where we applied a strategy are significantly higher.

A considerable part of the students were able to explain the physics phenomena conceptually.

We should widely apply the problem solving scheme not only in Bachelor level, but also in other level of education, in order to create students who can assimilate the physics concepts in a more logical way, instead of a mechanical way.

The departments in the faculties should be encouraged to use strategy in Teaching Physics and solving problems. Finally, the students of Natural Sciences will enjoy a higher efficiency and proficiency in their lives.

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Preservice teachers' understanding of the concept of relative speed using a video-based laboratory in physics education

Introduction

The modern way to teach physics, as prescribed by high school physics curriculum, requires teachers to take on new roles and modify their concepts about the nature of science and the acquisition of scientific knowledge (Anderson, 2002). Some researchers (Aiello-Nicosia & Sperandeo-Mineo, 2000) propose that student teachers experiment for themselves the scientific approach in an environment similar to that in which they will teach. Having student teachers reflect on their own learning process in this type of environment and providing them with educational tools for teaching physical models, aims to favor within the student teachers a better understanding of physical concepts of motion, of ways to plan an experiment to link the results to an initial hypothesis, and of the usefulness of models in planning and executing experiments. Hence, to gain a deeper understanding of the ways learners approach the study of kinematics, it is recommended to involve student teachers in researching this topic for the following reason. Some researchers explain that by acting as students, student teachers have the opportunity to gain pedagogical insights, and by acting as teachers, they have the opportunity to gain content insights (Bowers & Doerr, 2001). Therefore, by putting student teachers in the role of students, we may gain additional pedagogical insights. This additional benefit helps us achieve our research goals: as learners, the student teachers enable us to 'model learning of a group of students given specific conditions ... in a video based laboratory' and as future teachers, they help us identify ways of improving student learning. As a consequence, this paper tries to answer the following research questions:

1) How do preservice teachers as learners interact with specific kinematics software within the context of the teaching-learning sequence proposed on relative motion?

2) From an analysis of their learning paths, and their ongoing comments and reflections about it, which teaching strategies help preservice teachers develop conceptual understanding of relative speed?

Review of theliterature

Kinematics, defined as the study of the motion of objects without concern with its causes, has been chosen for this research since this topic presents many difficulties to students. There are two main reasons for these difficulties put forward by the researchers: alternative schemas which the pupils already have on the properties of motion and the emphasis put on the mathematical nature of motion properties in the high school physics laboratory. Firstly, the students have, before arriving in the Physics course, a broad experience with the properties of motion acquired in their interactions with daily events. This experience although useful in daily life may interfere with learning, especially if the teacher does not take them into account (Knight, 2004). We will treat in the next section the alternative conceptions about constant and relative motion and in the following section the emphasis in the science laboratory on the mathematical nature of its properties.

The alternative conceptions students already entertain about constant and relative motion properties.

Particularly, students' difficulties to understand rectilinear motion at constant speed have not been much studied in recent researches in didactics of sciences, the main researches on this subject having been accomplished near two decades ago (Crépault, 1989; Trowbridge & McDermott, 1980). In this respect, if certain authors state that high school students, for the most part, have acquired this notion (Siegler & Richards, 1979), others assert the opposite, notably with respect to the concept of relative speed (Lovell, Kellet & Moorhouse, 1962). Indeed, expressed as the quotient of distance and the corresponding time interval, the calculation of speed does not seem to cause particular difficulty in an idealized situation, such as it is often introduced in high school (Goffard, 1992). However, the pupils often stumble when they are confronted to more realistic situations. Let us consider, for instance, the case of a motorist moving from one city to the other at constant speed on a freeway. It is easy to answer questions with respect to the time required to reach the next city distant of 150 km if the speed is given (for instance, 100 km / h). Nonetheless, may think the student, before attaining a constant speed, the car must have accelerated. When the motorist reached his destination, he had to decelerate. What takes place before or after uniform straight movement should not intervene in the calculation of the requested time (Goffard, 1992)?

In another set of ideas, Crépault (1989) studied the qualitative reasoning of the pupils concerning different motions at constant speed. His conclusions reached those of Siegler & Richards (1979) as well as those of Trowbridge and McDermott (1980). According to these authors, there are several levels of understanding of the concept of the speed. At lower levels, the students judge the speed according to a single dimension (that it is the distance traveled, the arrival time or the final position). In an intermediate stage, rules used by students take into account both dimensions but by keeping one of them constant. At the highest level, the pupils can coordinate these two dimensions to judge the speed in arbitrary conditions.

Trowbridge and McDermott (1980) have uncovered the existence of a criterion of position used by the pupils to judge the speed. These authors gave, for example, the case of two cars running at constant speed in the same direction at different speed. Then, they asked the pupils if there was a time when both cars traveled at the same speed. Most of the pupils answered that during the interval of time when both cars traveled side-by-side, their speed was the same. It seems therefore that confusions between the dimensions of the speed (interval of time and interval of position) and the speed itself do not involve only initial or final conditions of motion but also intermediate ones.

Other difficulties appear, when we move away from canonical situations mentioned before by introducing a demonstration to pupil of a train toy which travels on a straight line by going through 45 centimeters in 1.5 seconds (Trowbridge & McDermott, 1980). After the pupil observed its motion, the researchers asked him which distance would the train go through in 2.5 seconds if it travelled at the same speed. According to the authors, the answer of this pupil is typical of difficulties encountered by the pupils in kinematics (Trowbridge & McDermott, 1980, p. 1022):

"Well that takes 1 ½ seconds, and it's 45 cm. Half of that would be 22 for ¾ ths, right? So that is ¾ ths of it, but I need a whole second. So that I quartered it again, and I got 11. And so I added the 22 plus 11 to the 45, and got 78."

According to Trowbridge and McDermott (1980), this wrong reasoning could not be explained by mathematical difficulties of the student since the resolution of this problem was within the reach of his mathematical competences. The error would rather be caused by his difficulty to interpret the quotient of the expression of the speed as a unique number (resulting from the operation of the quotient of distance and interval of time). On the contrary, this student continued thinking of the speed as a simple association between distance and the corresponding time interval (Arons, 1990; Trowbridge & McDermott, 1980).

As regards the evolution of the understanding of concepts of speed with age, it seems that the naïve comprehension of the pupils regarding motion is already formed at the youngest age and remain comparatively unchanged up to the adulthood (Eckstein & Shemesh, 1989). For example, concerning the inertia of objects in motion, which is closely linked up with the constancy of the speed of uniform rectilinear motion, these authors determined the prevalence of the intuitive or wrong notions of inertia in more than half of university students of a physics introductory course.

It appears therefore that the concept of constant speed does not seem to be mastered by the high school students and that naïve comprehension which they maintain in this respect continues, for the majority of them, up to the adulthood. Such situation cannot be discerned by the teacher if he offers to his students the simple problems of motion where a single object is involved and where initial conditions are determined beforehand (Reif, 2008). Difficulties appear when the situations of motion are introduced as part of experiments where real objects are put into play, and thus reintroduce the influence of context (initial and final conditions) in the problem solving process.

These problems are compounded in the case of pursuits or objects with parallel trajectories but with different speeds. Hence, the study of relative speed causes a lot of difficulties to students (Walsh & al, 1993). In cases involving relative speed, the initial and final conditions of their travel must be taken into consideration. Take for example, the case of a pursuit between cyclists in a professional competition (Mejia, 2008). The idea of "escape" means that one cyclist managed to increase his speed and maintain it with respect to the squad. If the peloton let him break away, the distance between the cyclist in breakaway and the rest of the pack will increase with time because the constant speed of breakaway cyclist remained greater than the average speed of the pack. If this situation continues, the advance of the breakaway cyclist will become insurmountable, given the distance remaining to the finish line, and the relative speed of the breakaway cyclist with respect to the pack. As a consequence, we can see here that this movement can be dealt with the concept of relative speed except for the brief moment when breakaway cyclist accelerated to a speed greater than the pack.

However, there is more to it than just putting the numbers given in the right formula. Indeed, to successfully solve this kind of situations, the student need to understand the various relationships between factors of constant motion and also being able to identify the situation as a relative speed motion, save for the brief moment of acceleration described earlier. Hence, contrary to the apparent simplicity of the formula of constant speed, its real motion, as involved in the case of pursuits, holds many subtleties.

Surprisingly, there are few studies that investigate students' understanding of relative motion. This situation is somewhat puzzling since this concept is important to the understanding of the concept of addition or difference of speeds. Indeed, the situation can be extended to all objects moving at constant speed relative to the one taken as reference. Changing of system of reference required that one changes his perspective about the motion. In some cases, it could help to uncover fundamental laws of nature. In this regards, Galileo proposed a thought experiment such as to imagine an object dropped form the top of the mast of a boat in uniform motion. Galileo make the hypothesis that the trajectory as seen by an observer on the boat will see a free fall motion and an observer on the shore will see a parabolic motion. He thus concluded to the independence of horizontal and vertical components in parabolic motion at the surface of the earth (Galilei, 1954). It also prepares the students to the understanding of key principle of modern physics, the principle of relativity (Panse, Ramadas & Kumar, 1994).

In this perspective, Walsh & al. (1993) studied qualitative reasoning of university and high school students about the concept of relative speed. As such, students were asked to solve the following qualitative problem (p. 1137):

> *"Martha and Arthur are running along a straight level road at constant speed. Arthur is ahead of Martha. Arthur's speed is less than Martha speed. How far must Martha run before she catches up with to Arthur, and how long will this take her".*

In analyzing answers of students, Walsh & al. (1993) have identified the following categories (please note that the most important point of each category has been underlined):

1) Relative speed as a new entity: in such a conception, the individual runners are integrated in a system in which a new quantity is constructed, the relative speed, in which the rate with respect to time of the initial distance between runners is reduced to zero. As such, one needs to consider the motion of one runner relatively to the other, who is considered as frozen. The system of reference is made explicit.

2) The runners are still considered as a system, but one in this category consider the distance between the runner as a variable quantity (a function of time) that is progressively reduced to zero (when Martha catches up to Arthur). Speed can de derived mathematically from the expression of the relative distance but it is not the focus of the solution.

3) Distance M = Distance A + initial distance. Martha runs the same total distance as Arthur plus the initial distance between them. The primary focus is on the individual runner running each a separate total distance with the individual distances related through the initial distance.

4) The focus in on the distance traveled separately by each runner. Indeed, it is recognized that each runner traveled during the same interval of time. Hence the time can be equated, we have: $Va = Da/t$ and $Vm = Dm/t$ so that $t = Da/Va$ and $t = Dm/Vm$. Equating time in the precedent equations, one is leaded to $Da/Va = Dm/Vm$. However, without making links between the two distances Da and Dm, this equation cannot be solved.

5) Discontinuous perspective: same discrete units of time. The focus is on Martha and Arthur running separately discrete units of time, with numerical examples that approximate the position and time they will meet, a stepwise calculation.

6) Discontinuous perspective: same distance. The initial distance between Martha and Arthur is acknowledged. The focus is on the distance each runner runs separately in the same time interval. Hence, the time it takes to Martha to cover the initial distance between the two is computed, say D1. Then the student proceeds to compute the distance covered by Arthur in the same time interval than Martha before, say D2. Then, student computed the time Martha took to cover the remaining distance D2. He then used this time interval to compute the next distance covered, such as D3, and so on. Although, Martha will get nearer and nearer of Arthur, the problem cannot be solved (Zeno's paradox).

The emphasis on the mathematical formulation of motion

Secondly, during laboratory activities, kinematics is often taught with an emphasis on applying the right formulas to get anticipated results (Arons, 1997). For instance, a common pedagogical technique consists in bringing students, at the beginning of the study of kinematics, to the laboratory where they measure different properties of motion which they then represent with graphs. Back in class, they analyze their results and perform calculations with the aid of mathematical expressions to get the values of the position, speed and acceleration with respect to time to confirm the graphed experimental data. And yet, it appears that the pupils perform these various operations without a real understanding of what they are doing (de Vecchi, 2006).

To overcome these difficulties, a video-based laboratory (VBL) has been proposed as a cognitive tool to help students develop more insights for the understanding of physics concepts (Escalada & Zollman, 1997). One major challenge for students is to recognize the connection between acceleration and real life situations. To meet this challenge, VBL encourages teachers to enhance students' problem solving skills by bringing interesting and complex real-world problems into the classroom and illustrating them realistically (Trudel & Métioui, 1992b). However, presenting the complexity of real-world problems using text can be difficult to understand for learners, who have limited experience and knowledge. The use of interactive video and dynamic graphics helps make understanding this complexity manageable even to average students. It also may increase the quantity and the quality of the experimental data obtained about scientific phenomena

Conception of the video-based laboratory (VBL)

The motion is recorded as video. The visual information is transformed into a numerical form by software which allows the measurement of the object's positions with respect to time. The data are organized in tables and graphics. In the learning sequence proposed, the kinematic modeling activities have been designed to study the characteristics of the following model: uniform motion (Halloun, 2004). The experimental set-ups used by the student teachers to study the properties of motion consisted of a rectilinear track of two meters long, one stainless steel ball and three universal supports. Student teachers were asked to assemble each set-up by themselves following the instructions given in the learner's guide. The ball can be made to roll along the track which can also be inclined (Fig. 1 and 2). As the experiments progressed, student teachers could capture the motion using a digital camera. The digital data were then copied to the computers using a USB connection. These computers contained programs called REGAVI and REGRESSI that are designed to conduct kinematics calculations using digital data of motion (Durliat & Millet, 1991). The student teachers were given specific tasks to complete with these programs, such as calculate the ball's position, speed and acceleration. The researcher acted as a teacher-facilitator by helping the student teachers throughout the lesson, just as a high school teacher would do with his students during a high school physics lesson. To enable student teachers to work together in pairs, we designed an activity guide that was used to manage the student teachers' lesson. The guide contained two cases for studying various aspects of acceleration concepts (Yuk Ko & Marton, 2004). Each case included activities (questions, graphics to be completed, etc.) that guided the student teachers' modeling process. The modeling process was structured as a POE task (Prediction> Observation> Explanation) (Gunstone & Mitchell, 1998).

We used a concrete set-up to study relative speed motion. We gave each preservice teachers an activity guide allowing him to work in small groups. We structure the physical situation as a scientific investigation. One gives a small impulse to the ball (A) in order that it rolls from one end to the other. The position of the ball A after 1 sec is given in the figure below. Seconds later, a second ball (B) is thrown with a greater impulse than ball (A) on a rail parallel to the first (Fig. 1).

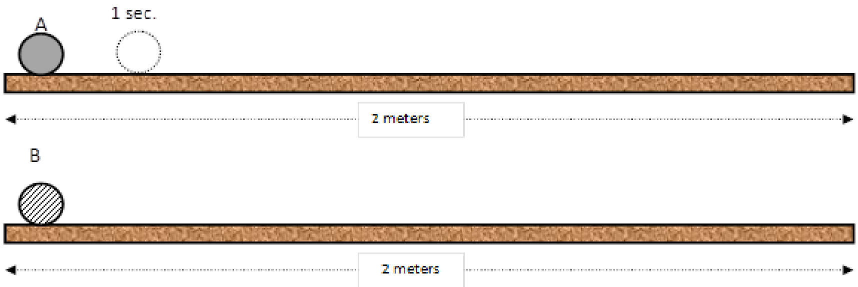


Figure 1. Schema of the physical situation presented to students

METHODOLOGY

Sample characteristics

The research participants recruited for this study were three male teacher candidates at the university where the study was carried out. As students in the teacher training program, they held a previous bachelor degree in science or an equivalent diploma. They were volunteers and had been selected because of their availability for the scheduled dates of the study which consisted in completing two activities where they studied the properties of motion and discussed with each other the scientific and educational aspects of the process.

Context of the teaching experiment

Activities took place in a special laboratory room where four cameras covered most of the area where the future teachers completed the activities and two cameras recorded the student teachers' interactions with their respective computer (Fig. 2).

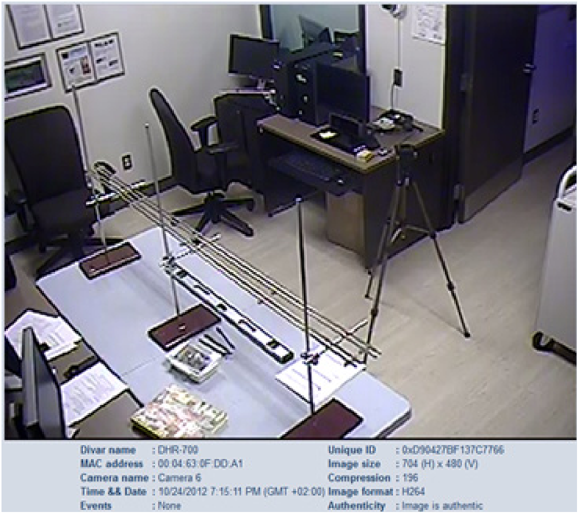


Figure 2. The laboratory room

Research protocol

The activities were held in a single session of 2.5 hours duration scheduled during the session study week. Activities took place in a special laboratory room where four cameras covered most of the area where the future teachers completed the activities and two cameras recorded the student teachers' interactions with their respective computer (Fig. 2).

One member of the research team acted as the teacher during the study. His role consisted of introducing the activities to student teachers, of assigning them roles during small group discussions, and completing in a plenary the analysis and synthesis of their results at the end of each activity period. As such, the researcher was present during each activity. The researcher also played the role of lab monitor to help with difficulties that arose in the set-up, the software data collection or analysis obtained by the student teachers. He introduced them to the required computer programs features before student teachers had to use them for data collecting and analysis in each activity. He also led a discussion with student teachers at the end of each activity to summarize their results and discussed the difficulties encountered as well as their suggestions to improve the activities (Rodrigues, Pearce & Livett, 2001).

Data collection and analysis methods

This study implemented a qualitative case study approach for collecting and analyzing the data (Karsenti & Demers, 2011). The researchers explored in depth the interaction of the two student teachers with computer modeling software program while they were studying the concepts of speed and acceleration. A time limit was placed on the learning activity during which the researcher collected detailed multimodal information using student teachers' artifacts and videos developed during the learning sessions (Kress, Jewitt, Ogborn & Tsatsarelis, 2001). Additionally, we set out to use the participants' artefacts to identify preconceptions that seemed most likely to affect their understanding of speed and acceleration. Specifically, we were trying to ascertain participants' expectations of the graphical representations of object motion as well as their preconceived ideas about the concept of acceleration as observed in the experiments or from the graphs.

To study the learning process of student teachers, we analyzed the content of the activity guides student teachers had to fill. Content reported by student teachers in these guides were expressed in different ways: text when answering questions, iconic in sketches of the moving ball, Cartesian graphs when predicting position-time and velocity-time aspects of motion. Qualitative data collected in these various forms of presentation received a categorization analysis (Miles, Huberman & Saldaña, 2014).

PRESENTATION AND ANALYSIS OF RESULTS

We present here the results of each pre-service teachers as a distinct case (Yin, 2014). The results of each pre-service teacher will thus be presented to describe more fully their learning step. Please note that each student teacher (ST1, ST2 and ST3) had to analyse the data of the video of motion with his own computer, using Regavi and Regressi software programs as described before. First, we will present for each one his predictions about relative motion of the tow balls rolling on parallel tracks about position-time and speed-time graphs how he explains his results.

Results and analysis of the results in the first case (ST1)

With respect to the first student teacher (ST1), his prediction about relative and more precisely, his prediction about if ball B thrown a little later will catch up with A. If yes, the guide asked him to draw on the figure the position of the meeting of the two balls.

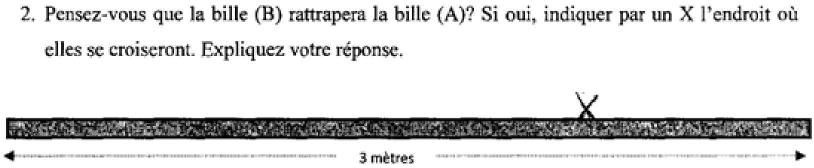


Figure 3. Drawing of the meeting point of the two balls according to prediction of ST1

When asked in the guide to draw the positions of balls A and B, he drew the following positions, indicating the corresponding time at each position (see fig.)

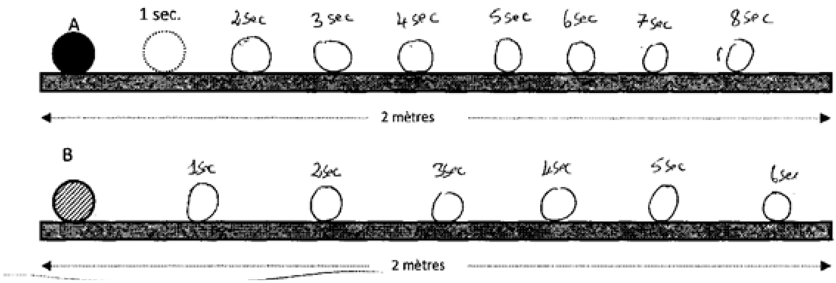


Figure 4. Drawing of the positions of the two balls according to predictions of ST1

When asked to justify his prediction, he wrote (free translation):

"Since the ball B is started with a larger impulse and it rolls at a constant speed, the distance it travels at a given time will be greater than that of the ball A at the same time. So balls A and B will meet at some point of their journey."

From the drawings of ST1 (Fig. 4), one can remark that the distance traveled by ball B is greater at each second than ball A. However, St1 did not indicate the time delay that B leaves the left after ball A. In fig. 4, he indicated that the first position of the two balls correspond to the t = 1s. This is somewhat contradictory since he predicted that ball B will catch up with A at before the end to the track. How could it be since the two balls departed at the same time and that B had a greater speed. Please note also that the distance at each interval are equals from onetime interval to the next, for the two balls.

The predicted graphs by ST1 are consistent with his drawings of the trajectory of the two balls A and B (see Fig. 3 and 4) and hence, his position and speed-time graphs (predicted) look the same as the corresponding predicted drawings of ball A and B (see Fig. 5 and 6). Thus ST1 thinks that the speed of both balls A and B are constant, with graph of the speed of ball B being higher than ball A, as is respectively the slope of position-time of ball B is greater than Ball A. Please note also that ST1 did not include a time delay in the graphs of position-time and speed-time of ball B.

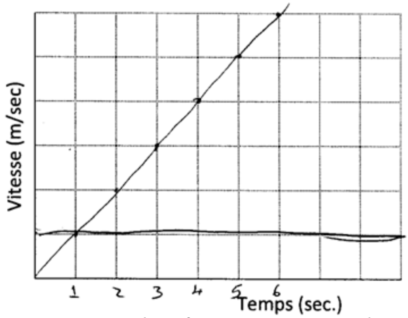


Figure 5. Graphs of position-time and speed-time of ball A

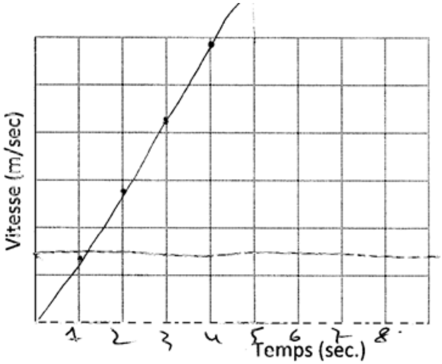


Figure 6. Graphs of position-time and speed-time of ball B

ST1had also to produce experimental graphs of position-time and speed-time of balls A and B. ST1 chose to compare the two graphs of position-time of balls A and B (Fig. 7)

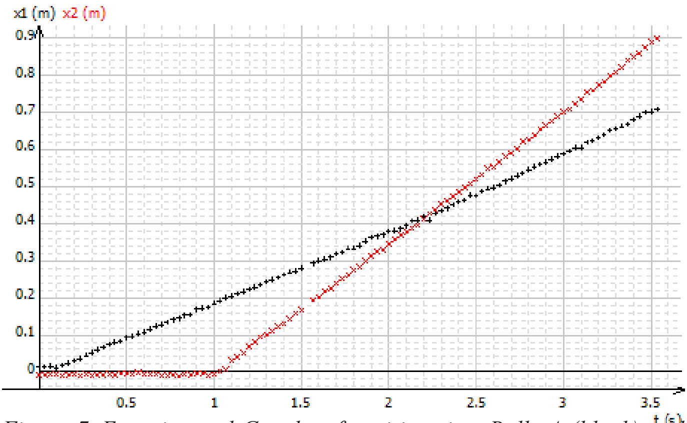


Figure 7. Experimental Graphs of position-time Balls A (black) and B (red) obtained by ST1

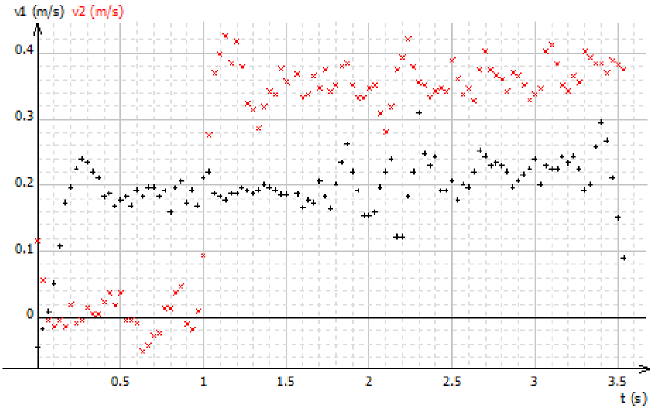


Figure 8. Experimental graphs of speed-time of balls A (black) and ball B (red)

When asked to compare his results with his predictions of speed-time graphs of balls A and B, ST1 answered that, the position-time graph he obtained from experiment with ball A was similar to the one he predicted but the one obtained via experiment of ball B was different from the predicted one because of the time which is one (1) second delay. He also asserted that, in no time, balls A and B have equal speeds, because each ball has the same speed from start to finish. Finally, he also advanced that ball B's speed is greater than A as it is launched with a larger impulse.

Presentation and analysis of results in the second case (ST2)

With respect to the second student teacher (ST2), his prediction about relative motion and more precisely, his prediction whether, if ball B is thrown a little later than A with a larger impulse, it will catch up or not with A, he answered to both questions saying that he did not have enough information to answer. Where the guide asked him to draw on the figure the position of the meeting of the two balls, he did not draw any point that could be the point of meeting (fig. 3). However, he drew equal distances for all the time intervals in the trajectory of ball A (fig. 3).

3. Sur la figure suivante, marquez les positions attendues de la bille (A) et la bille (B) lors des secondes suivant l'impulsion. La position de la bille (A) à 1 seconde est déjà indiquée. Rappel important : la bille (B) a été poussée avec un certain retard par rapport à la bille (A) (disons 2 s) mais avec une plus grande impulsion.

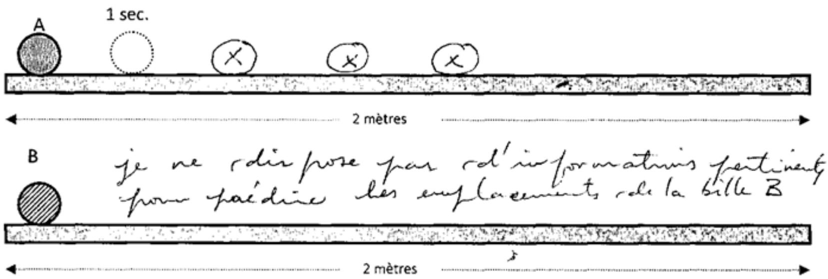


Figure 9. Drawing of the positions of the two balls according to predictions of ST2

When asked in the guide to draw his predicted graph of position-time and speed-time of balls A and B, he did no drawings. Finally, he did produce experimental graphs of position-time and speed-time that looked similar to ST1's graph, except that with respect to these graphs, he presented them separately instead of comparing them directly as for ST1.

When asked in the guide to compare his predictions and experience, ST2 stated that, with respect to the position-time, the ball A takes 2 seconds to travel 2.5 m while ball B will take 2s to travel 3m. With respect to speed, ST2 wrote in the guide that ball B had a greater velocity than A. Ball A will maintain a constant speed and be ahead of ball B which is then launched but will catch up later. The ball B will retain its speed that remains larger than A and will outperform it. The two speeds A and B are different because for the same time interval, the distances are different.

Presentation and analysis of results in the third case (ST3)

With respect to the third student teacher (ST3), when asked if he thought that ball B would catch up with ball A, he answered that, for sufficiently long rails, ball B would catch up with ball A. However, according to him, it may be, that with the set-up used, we could not see this phenomenon (too short rails).

When asked to indicate the position of their meeting, he drew the following figure.

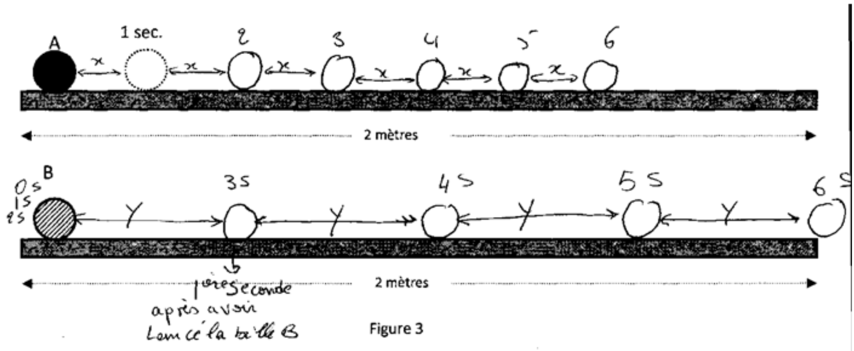


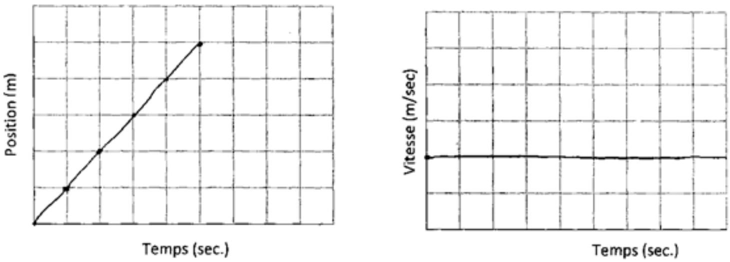
Figure 10. Drawing of the positions of the two balls according to predictions of ST3

By inspecting figure 10, one can see readily that ST3 have represented the principal elements of the scientific representation of the motion of the two balls A and B. Indeed, the distance across successive time intervals is the same for the two balls, meaning that ST3 acknowledged the uniform character of the motion of the two balls. One key aspect of this representation is the inclusion of the initial conditions (time and position). Indeed, he situated his system of reference at the left of one of the track (on which rolled ball B). Furthermore, he clearly stated by writing (free translation) under the position of ball B at 3s: "1st second after having launched ball B".

With respect to his predicted graphs of position-time and speed-time, they are consistent with his drawings in figure 10. As is the case for ST1, ST2 thought also that the speed of both balls A and B are constant, with graph of the speed of ball B being higher than ball A, as is respectively the slope of position-time of ball B is greater than Ball A. However, contrary to ST1, ST2 included a time delay both in his predicted graph of position-time and speed-time of B. Please note that the tabular form of figure 11 where the graphs of position -time and speed-time constituted the first and second column and the information about balls A and B constituted the first and second line (Fig. 11)

6. À partir de vos réponses au numéro 3, tracez ci-dessous les graphiques des positions et des vitesses des deux billes tout au long de leur déplacement.

a. Le graphique position-temps et vitesse-temps pour la bille (A).



b. Le graphique de la position en fonction du temps pour la bille (B). Rappelez-vous que la bille (B) est poussée avec quelques secondes de retard mais avec une plus grande impulsion.

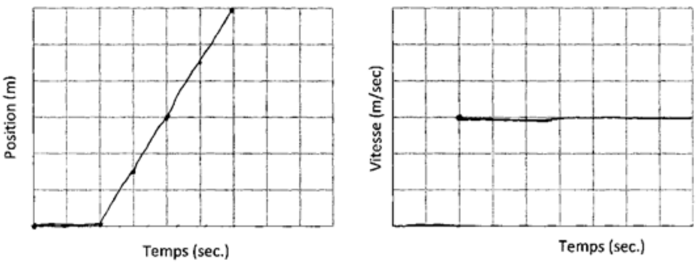


Figure 11. Predicted graphs of position-time and speed-time of ball A according to ST3

When asked to compare the experimental graphs he obtained with his predictions, ST3 stated that, with respect to position-time, the experience confirmed his hypothesis. Indeed, the positions versus time predicted curves were similar to those obtained by experiment. With respect to speed, ST3 added the following comments. With respect to ball A, ST3 consider that its motions was uniform, his speed was constant. With respect to ball B, he stated that the ball was at rest until it received a pulse. She subsequently underwent uniform motion at a constant speed. Finally, he explained that the speed-time graph of ball B was greater than that of the ball A.

Discussion

According to our student teachers, the ease with which the computer produced different types of representations allowed them to test their hypothesis about relative speed more easily and more thoroughly. Firstly, the possibility to rerun at will the video of motion of the balls helped them to discern the principal characteristics of relative motion and identify its critical aspects. It also produced traces of the motion that would have been impossible to discern with the naked eye. Indeed, being able to construct a trajectory is the first step toward discerning the relationship between the various quantities of relative motion (Meli, 2006).

In addition, one can wonder what can mean the use of VBL in the context of scientific inquiry to favor conceptual changes among high school students? One can imagine using the VBL to verify some specific hypotheses (or in a pedagogical context one can say predictions) involving comparisons between situations of uniform motion and build on the results obtained to find a more general solution (Hoz, Harel & Tedeski, 1997). To this end, these authors made a list of possible problems or fact patterns that connect with the factors of relative movement or the speed of the two objects, the initial and final conditions of the movement and the links these various quantities. By listing the various problems that can deal with this scheme, they seek to establish experimentally the factors that students must take into account in reaching a solution depending on the type of problem that is proposed. They discovered that, depending on the speed comparison problem, some strategies lead to success more than others.

Referring to the categories of Walsh et al. (1993), the future teacher ST1 can be classified in the category of the consideration of the distances of the two balls in an independent or separate way or separately. Indeed, he did not establish links via the initial conditions (existence of a time delay between the launching of the two balls). His speed-time graphics drawn from these predictions reflected the idea of a comparison of speeds only (the graphics are made in separate way without making any link between the two movements) and his reasoning emphasized that since the ball B will travel faster than the ball A, it will inevitably catch up with the last one. Moreover, he did not question or take into account in stating the specific conditions of the meeting the existence of a time delay (the longer distance traveled by B during the same time than A it will allow B to catch up with A).

The respect to case 2, the second future teacher is even more noteworthy. He began by stating that he did not have enough information to answers the questions in the guide. Then, he described the motion of the two balls in separate ways. Moreover, he alternated his descriptions of the two balls along successive segments of their trajectories. As a consequence, we can classify him in one of the lower levels of categories of Walsh and al. (1993) with respect to qualitative understanding of relative motion. As for ST3, his conception of the relative speed is the one that is the most closely associated with the scientific conception. As such his main argument is focused on the distance traveled by each runner but he related their initial time by including a time delay. Although he did not indicate the meeting point of the two balls, he had written all the information needed to do so.

Conclusion

VBL can give student teachers the possibility to review at will and even stop the motion at some critical points, can give them also an idea of the relation between various quantities (time, position, speed) and allow easy access to test quickly and efficiently various hypothesis emitted by them. As such, VBL may be viewed as a cognitive tool to help student teachers actively compare their mental representation with various multiple representations. As for now, science education research had concentrated on identifying naive conceptions formed before instruction. However, there has been recent calls to investigate conceptions of students in more complex phenomena that are likely to arise during and after teaching. This study has the advantage of showing us that speed comparison problems, and thus relative speed, may be of great complexity. Understanding the concept of relative speed may, among other goals, lead students to understand better the role of initial conditions in problem-solving in kinematics. Indeed, while studying Cartesian graphs of position-time and speed-time in relative motion problems or experiences, students may make links between quantities such as the area below the speed- time graph and the distance traveled by the body and also connect the slope of the position-time graph with speed. This multiple-cases study involving only three students cannot claim the generalization of results or transfer to the classroom. This research may help to clarify the opportunities that ICTs offers to inform us about the process and difficulties of students with respect to physics concepts such as relative speed using different modalities. Future research should involve a more diversified sample of student teachers as well as to cover more scientific disciplines.

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Mastering the concept of chemical reactions rate after the bachelor degree preparation of future teachers at the Faculty of Natural Sciences of Comenius University in Bratislava

Introduction

For the application of the constructivist approaches in the basic concepts of chemistry in the preparation of pupils at primary and secondary schools, we have to assure deep mastery of these concepts while in undergraduate courses for future teachers of chemistry. It is necessary a condition for developing their didactic preparation in master´s degree of study, which can be based on this deep mastery of concepts of chemistry and contemporaneously it, allows to prepare them for didactic interpretation for the construction of knowledge of students at primary and secondary schools.

In our contribution we analyse the results of a study aimed at diagnosing the level of understanding of the concept of chemical reactions rate by graduates of bachelor´s degree of study of all teaching combinations at the Faculty of Natural Sciences Comenius University in Bratislava.

As a research tool, we used diagnostic instrument RCHR (it is abbreviation for the rate of chemical reactions), that was created for deeper findings of pupil´s and student´s interpretations of the mentioned concept the chemical reactions rate. The tool was created for the research in project VEGA-14-0070 called Science curriculum for primary schools 2020th.

Detailed characterization and verification of its properties was introduced to didactic public at an international conference ScienEdu (Prokša & Michalisková, 2016). At this place, therefore, we will not occupy by detailed theoretical basis in the creation of this instrument. We will adduce only the basic characteristics of mentioned testing instrument and methods of evaluation and interpretation of collected data. Our attention we will focus mainly on the results of the study with an emphasis on diagnosing preparedness of future teachers of chemistry based on the depth of understanding in mentioned chemical concept.

Objectives

The basic objective of the research investigation was to diagnose the mastering of the concept chemical reactions rate by future teacher of chemistry after the bachelor degree of study, which is focused mainly on the preparation of students in chemistry.

We wanted to diagnose the level of mastering concepts in two-dimensional space. The first dimension represented the level of understanding on memory, algorithmic and conceptual level. The second dimension was represented by macroscopic, sub-microscopic and symbolic representations of the concept and their actual interconnection to solve conceptual problems.

Additional objective was to found out how the bachelor's degree of preparation of chemistry at the college affects and changes the level of interpretation of mentioned concept that the students brought from secondary school. For achieving the goal, we therefore incorporated into the study two groups of students. The first group consisted of students who study at Faculty of Natural Sciences in Bratislava teaching of chemistry so they have completed an undergraduate training in chemistry. The second group consisted of students, who also study teaching, but it does not contain chemistry. These students therefore have not completed an undergraduate preparation of chemistry at college. The research sample, which we designed and used, had the potential to deeply identify the impact of university preparation in chemistry in mentioned concept, because the half of research sample did not pass this preparation.

Method

The research was conducted through test method conceived by our didactic test RCHR from the topic chemical reactions rate.

RCHR testing tool indicates mastery of this concept at all of three levels of its representation, thus macroscopic, sub-microscopic and symbolic, which are interconnected. It diagnoses the causes of a formal interpretation of the mentioned concept of pupils and students without real grasp, active use in different and also well or lesser known conditions and contexts.

The test is described only in general terms. The reasons were set out at the beginning of our article. Our test instrument was made up of 17 test items. One item was focused on clustering (Prokša & Michalisková, 2016) and the remaining items were two-level tasks (2 + 3, 4 + 5, 6 + 7, 8 + 9, 10 + 11, 12 + 13, 14 + 15, 16 + 17). Two-level items were made up of two parts that formed the whole. In two-level tasks 2 + 3 and 16 + 17 was necessary in both parts form a short answer. Other two-level tasks were designed so that in the first part students could choose the right answer from four options that was offered. In the second part of two-level tasks was necessary to give a reason, why they choose selected option in their own words.

The tasks formulation allows to quantify the performance of the respondents, because it was possible to assign by points each partially correct and completely correct answers. Then we could consider quantitative individual tasks, individual two-level tasks and test as a whole too. In the analysis of results of research, it was also possible to apply frequency analysis in examination of the first and second components two-level tasks.

For better illustration lists an example of the wording two-level task 2 + 3.

2. In beaker A is 250 ml of 30% hydrochloric acid, which having a room temperature and 2 g of zinc metal. Write you chemical equation of chemical reaction that takes place in the reaction mixture in a beaker A.

In students answers we expected and evaluated the accuracy and completeness of symbolic representation of a chemical reaction of zinc and acid. The most expected answer was: $Zn + 2HCl \rightarrow ZnCl_2 + H_2$.

Exceptionally, we thought about the ionic enrollment of reaction.

If students wrote correct equations of chemical reaction, we assigned them two points. If students wrote only partially correct answer (wrong stoichiometric coefficients, error in the formula), we awarded one point. When students gave otherwise incorrect equation in their answer, or did not solve tasks they received zero points.

3. Write which changes showing that a chemical reaction goes, we will observe in beaker A.

The most likely answer was leakage of hydrogen bubbles. The accuracy of the formulation could be quite wide - from "bubbles" to the formulation mentioned above. In the answer students could mention heat staining of reaction too, for example "heat the beaker." Similarly, the less likely was also the formulation as "depleted of zinc", "zinc loss" and so on. In the case of putting all three options in students answer we awarded them three points. If miss one of the mentioned visualisations of the chemical reaction, we assigned two points. If was given only one visualisation of chemical reaction, we awarded only one point. In other cases, we assessed the answer of students by zero points.

If we assessed the tasks 2. and 3. as a single two-level items, the maximum possible score in two-level task was given the sum of the points in task 2. and 3., thus five points.

Whereas the tasks 2. and 3. formed one two-level item, we could evaluate them through a frequency analysis. We could connect the symbolic representation of the chemical reaction with the macroscopic representation. Subsequently, we could do the interpretation of occurring or absenteeism visualisations with respect to the accuracy of symbolic writing of reaction.

Testing took place at the beginning of the school year (September) 2015/2016. It was attended by 41 students of the first year of master degree of study of all teacher combinations of Faculty of Natural Sciences Comenius University in Bratislava. This sample of students represented available selection. It represented almost all students (over 91 %) that studied in a given school year teaching of some subject at the Faculty of Natural Sciences Comenius University in Bratislava.

The sample size allows us to interpret the results as a case study, with the potential to outline some trends in research problems, verify and precise methods and means used to achieve the objectives. It allows to know the possibilities and limitations of interpretation of the data. This initial investigation we will extend in the next time and then we can generalize conclusions based on the obtained results. At this time, we do not want to do.

We didn´t provide to students beforehand any information, that they will be tested so they didn´t have the opportunity to prepare and to study again a given problem beforehand. The information about the range and character of student's mastery of knowledge we thus acquired the hindsight not as soon as was taught the mentioned theme. The knowledge with which we will work are therefore part of the basic structure of the knowledge of individual students.

Testing took place on teaching subject of Methodology of educational research, so that all students solved the test simultaneously in one school hall. At the beginning of testing, we told all student all the necessary information about testing, we explained to them our research objectives and we told them how to proceed in solving individual problems. Finally, we requested them to sit down so as to not disturb each other, do not advise on neighbour and do not affect each other and then we told them to leave on the table just needed stationery. Then we handed out the assignment to students and answer sheets in which students had to write the correct answer. If a student did not know something, they could raise his hand and we provide them the necessary information.

To solving the test, we gave students 30 minutes. After this time, the students had put their pens on the table and we could collect the test assignment and answer sheets too.

Results and Discussion

Evaluating of student's answers was implemented in several levels. In the first we assigned appropriate number of points each task for completely correct solution, partially correct solution or incomplete solution and zero point for false solution or in case that task wasn´t solved. Overall, it was possible for completely correct solution of the whole test get 34 points. In the next step, we then calculated the relative success of all students throughout the test, expressed as a percentage - Figure 1.

The graph shows the distribution of success of students in terms in the whole test of the survey sample. The distribution of the results from this aspect, as we expected, indicating the validity of the next evaluation, analysis and interpretation of the data.

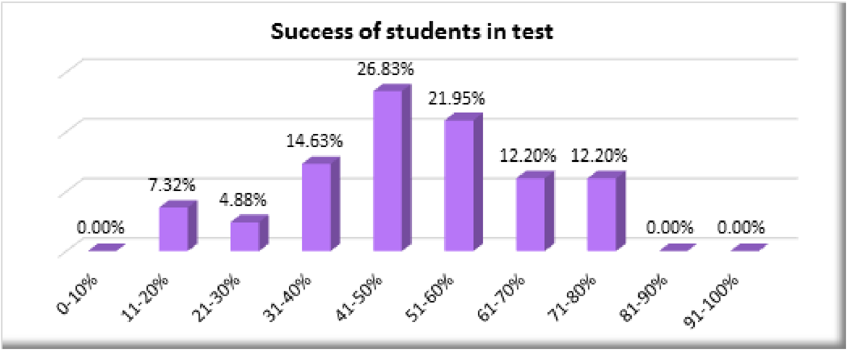


Figure 1. Distribution of students success throughout the test

We did an analysis of the relative success of all students in each item again considering the whole research sample. The results of our research are shown in Graph 2.

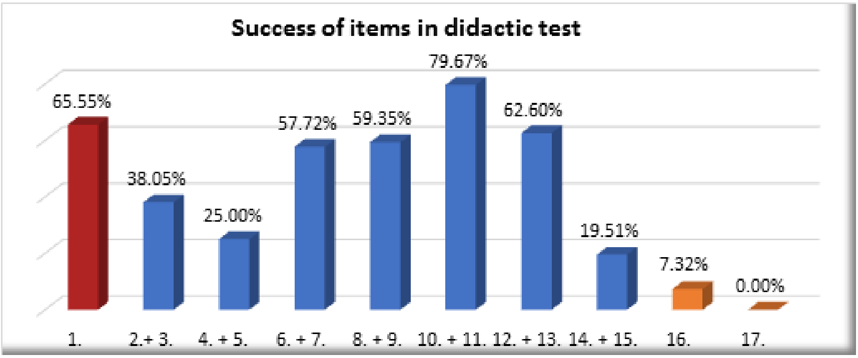


Figure 2. Success of students in each item

In the graph 2 due to the very low success in two-level items 16 + 17 we show success of each item of this two-level item (items 16 and 17) separately.

The results of students in the first item, which was focused on clustering and which was related to the chemical reactions rate, we could describe as quite good especially with regard to the success of all items of our test. They declared quite good overview about concepts that are related to the rate of chemical reactions. The concept rate of chemical reaction had students integrate into the structure, which they could declare even in this less known task.

In two-level items we investigated how students perceive the impact of certain factors on the rate of chemical reactions. At the same time, we demanded from students to justify and explain in detail their arguments about how all factors affect the rate of chemical reactions. Reasons and explanations weren´t at such a level as we expected from students of Master degree of study and future teachers of chemistry. Finally, we considered as correct a relatively simple answer. After the analysis of the answers of all the test items we found that students were the most successful in the two-level item focused on the effect of temperature on the rate of chemical reactions (10 + 11). This item success reached almost 80%. Next followed the two-level items 12 + 13 and 8 + 9, which was focused on the effect of the reaction surface of reactant on the rate of chemical reactions. Items reached the success around 60%. Then followed two-level item 6 + 7 that was devoted to the impact of increased volume of acid at the rate of chemical reactions. The items success reached almost 58%. The majority of students could refuse the argument that the change in the volume of acid without changing its concentration affects the rate of the chemical reaction. The two-level items 2 + 3 and 4 + 5 hadn´t a high level of success. The reason was probably that the items was focused on the combination of knowledge belonging to several levels of interpretation. The students had to associate knowledge on a macroscopic level with the knowledge on a symbolic level and also knowledge on sub-microscopic level with macroscopic level.

Very low access was in two-level item 14 + 15, which was focused on the effect of the catalyst respectively inhibitor on the rate of chemical reaction. The low access of this item was probably due to the fact that students didn´t know chemical properties of urea as inhibitor and therefore couldn´t determine how a given chemical compound affects the rate of a chemical reaction.

As can be seen in Figure 2, the least successful entries were 16 and 17. At issue was necessary to give a short answer in the form of respect for the definition of a chemical reaction speeds and units, which indicate the size of the rate of chemical reaction. It was surprising that the students studied teaching of chemistry reached low level of success.

The next step is the evaluation and interpretation of the data we ascertain that there is a difference in the results of students of teacher studies at the Faculty of Natural Sciences Comenius University in Bratislava between those who have completed an undergraduate training in chemistry (certified competence with chemistry) and students who have such training did not attend and respond to the test build the individual grasping the concept of speed of chemical reactions only of secondary level.

We got out of the natural working hypothesis that we find a statistically significant difference in favour of the more successful "chemists". In the next section we present results that provide us with statistical software Statgraphic. We present them in the form of the program.

Table 1. Summary statistics

Characteristic	*non-chemists*	*chemists*
Sample size	20	21
Aritmethmetic average	12,75	20,2381
Štandard deviation	3,86448	3,59033
Variation coefficient	30,3097%	17,7405%
Minimum	6,0	13,0
Maximum	20,0	26,0
Range	14,0	13,0
Štandard skewness	-0,613966	-0,427645
Štandard kurtosis	-0,210602	-0,601667

Comparison of results of the survey also are expressed in Fugure 3.

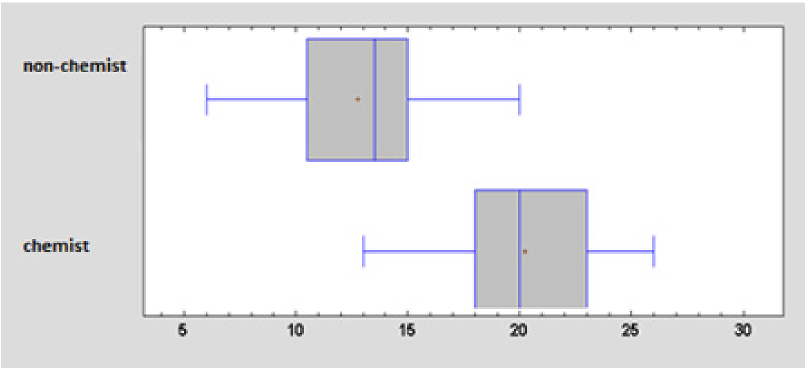


Figure 3. Comparison of the results of students of chemical and non-chemical approbation

The values of standard skewness and kurtosis are in range from -2 to 2, so we could consider the data as normal distributed, and therefore we could use on comparison of the results of chemist and non-chemist the parametric Student t-test.

Its value t = -6.43151 on the 95% level of statistical significance indicates that the arithmetic mean of achievement of chemists and non-chemist are statistically significant different in favour of better achievement of chemists.

We could accept our working hypothesis. Students who graduated the bachelor preparation of chemistry was in our didactic test successful. Non-chemical way of study, longer lapse of time to the handling of a given concept and above all lower merely secondary-school level of mastery of the mentioned concept were probably signed to lower success of this group of students. Bachelor course of chemistry for students who study teaching of chemistry therefore increased the preparation of students in understanding of the concept the rate of chemical reactions.

Analysis and evaluation of individual test items

Analysis of individual answers should show the knowledge of students of first class of master's degree of study at Faculty of Natural Sciences Comenius University in Bratislava in the field rate of chemical reactions. Due to the fact that our didactic test was focused on chemistry and testing was attended by students of all teacher's combinations, we divided them according to their fields of study into two groups - chemists and non-chemists. We did it because we wanted to compare the knowledge of students who study chemistry with students who study other fields. We could then assess influence of the study of chemistry at the Faculty of Natural Sciences on knowledge of students who study teaching of chemistry. We wanted to know if this study enhanced students by new knowledge or whether their knowledge remained at the same level which acquired at secondary school.

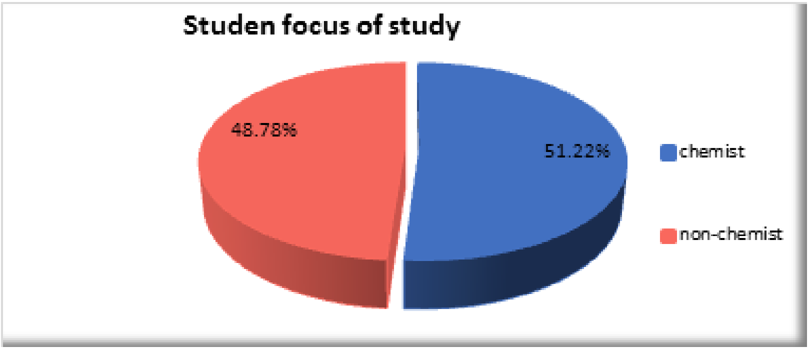


Figure 4. Distribution of students into groups chemist / non-chemist

Task 1

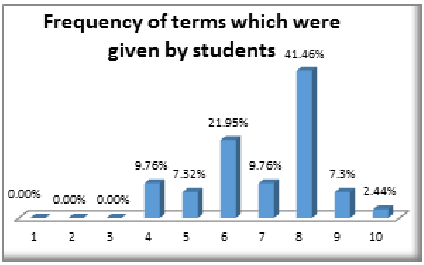
The first task was focused on concepts related to the rate of chemical reactions which students in their first year of Master´s degree of studies. Students' role was to write to the scheme 8 concepts which are related according to them with the rate of chemical reactions.

First of all, we expected in the students' answers concepts related to the factors that affect the rate of chemical reactions - concentration, temperature, catalyst, inhibitor, reactant surface and pressure. We expected also concepts related to the reaction mechanism of chemical reactions - reactant, product, activation energy, activated complex, energy of activated complex, particle collision, the effective collision, the orientation of the particles, the chemical reaction. Closely related concepts with the rate of chemical reactions we considered concepts like kinetics, time, slow reaction, fast reaction, velocity constant, an indication of the velocity constant **k**, an indication of rate **v**. Acceptable answer was if a student wrote, for example, the unit of rate of a chemical reaction, the formula for calculating the rate of a chemical reaction or general chemical terms like particle, molecule, chemical bonding, chemical equation, which are in wider meaning also associated with the concept of the rate of chemical reactions.

For each correct concept that students wrote, they could get 1 point. Total score of this task was given therefore by summation of all individual scores for concepts related to the rate of chemical reactions. Concepts that were related to the rate of chemical reactions only very marginally or were unrelated to this concept, we evaluate by 0 points.

The quantitative evaluation of this item shows that all students adduced at least 4 concepts (it is half of the total required number of concepts), which were according to them related to the rate of chemical reactions. Even more than half of the respondents (51.22%) wrote maximum number of concepts that we required (8).

After a thorough analysis of all concepts, we conclude that some of them with the rate of chemical reactions unrelated. Thus, we created a slightly different view on the issue. Frequency of concepts that really were related to the rate of chemical reactions was shifted to a lower level. In this case, there were 4 or more related concepts reported by around 90% of respondents. All 8 concepts associated with the rate of chemical reactions that were needed to give were written by 12 % of students. Respondents therefore declared pretty good readiness to give a correlation of the selected key concept with other related concepts.



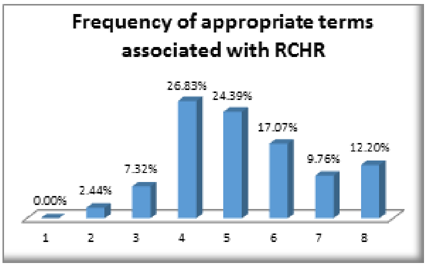


Figure 5 and 6. Quantitative analysis of the terms occurring in task 1

If we had to quantify the concepts that were mentioned in connection with the rate of chemical reactions between chemists and non-chemists, the situation is relatively balanced between the two groups (shown in Figure 5 and 6). While all chemists were able to write 5 or more concepts, which were according to them related to the rate of chemical reactions, non-chemists managed to put 4 or more concepts.

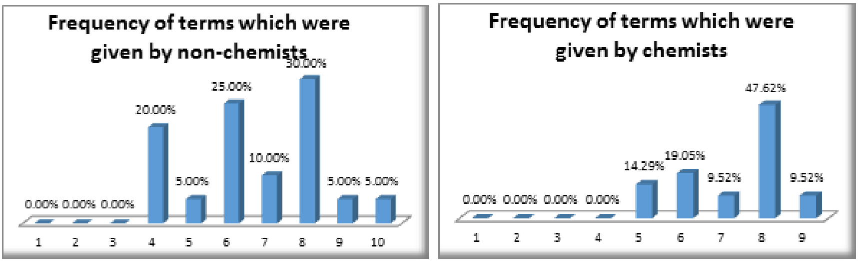


Figure 7 and 8. Quantitative analysis of the terms, which were given by non-chemists and chemists

After an analysis of these mentioned concepts were deleted the inappropriate concepts and we found out that the frequency of appropriate concepts related to the rate of chemical reactions in the two groups decreased (Figure 7 and 8). Significant decrease was recorded in group that was formed by non-chemists, what we even expected.

From all non-chemists just 80% of them could give at least 4 and more appropriate concepts that was in relation to the rate of chemical reactions. The most commonly they wrote just 4 concepts (45%). All 8 concepts that we expected of them were given only by 5% of non-chemists.

In the group that was formed by chemists were able to write 4 or more appropriate concepts all respondents. All 8 expected concepts was reported by 19% of them.

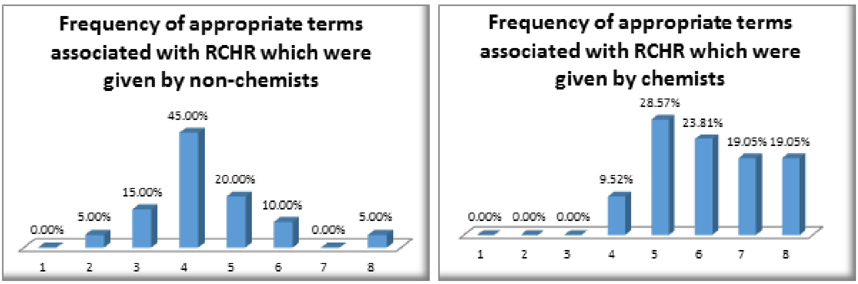


Figure 9 and 10. Quantitative analysis of the terms, which was given by non-chemists and chemists

Quantitative analysis of concepts referred to in student's answers shows that some of the concepts were related to the rate of chemical reactions and others had more likely the character of concepts that were not related to a given concept.

In Figure 9 is shown that more than half (65.72%) of adduced concepts belong in the category of concepts which were closely related with the rate of chemical reactions. In that category were included concepts associated with the factors affecting the rate of chemical reactions or with reaction mechanism. Another 9.54% of concepts were classified in the category of concepts associated with the rate of chemical reactions, but in a slightly wider sense. That were the general concepts related to chemical reactions. Almost 5% of that concepts were associated with visualisations of chemical reactions and with the experiences gained during the exercises in the chemical laboratory. The remaining approximately 13% were concepts that we ignored, because the concepts were in very little connection with the rate of chemical reactions, or they weren´t related at all with mentioned concept or were a meaningless concept. In this category we included concepts such as the half-time of decay, density, chemical equilibrium, photosynthesis, oxidation, reduction, mol/s, v = t.c, decay, track, change, love, reaction force, excitation, oxygen, anions, cations.

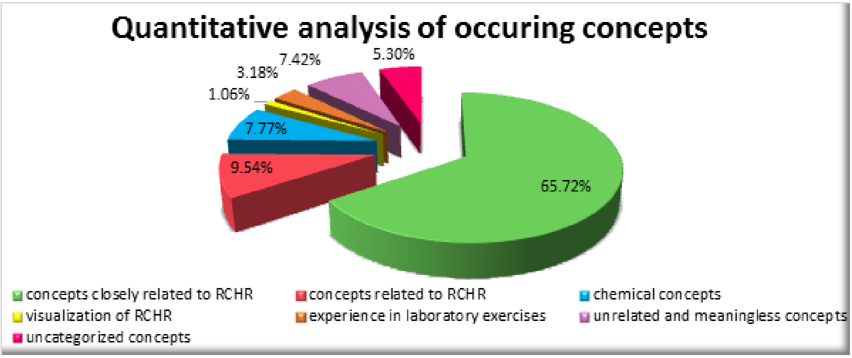
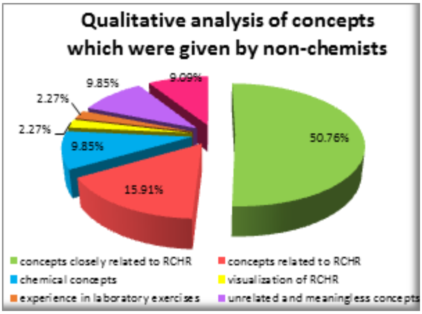


Figure 11. Qualitative analysis of occurring concepts

Comparison of the adduced concepts in qualitative aspects in groups of chemists and non-chemist showed that chemists disposed of more concepts that were closely related to the rate of chemical reactions. Chemists were able to put about 79% of the concepts closely related to the rate of a chemical reaction and it was about 29% more concepts compared with non-chemists. A further 4% were concepts related to the rate of chemical reactions in wider sense. Then there were about 6% of concepts belonged to the category of chemical concepts that have been very broadly related to the rate of chemical reactions. Less than 4% were concepts acquired during the laboratory exercises. The remaining approximately 7% of concepts were classified in the category of unreasonable or unclassifiable concepts.

In the category of non-chemist, it seemed that with the rate of chemical reactions was related to about 66% of concepts. The other 2% were concepts associated with visualization of chemical reactions. Nearly 10% were chemical concepts that with the rate of chemical reactions related only very marginally. Approximately 22% of the concepts we included into the other categories.



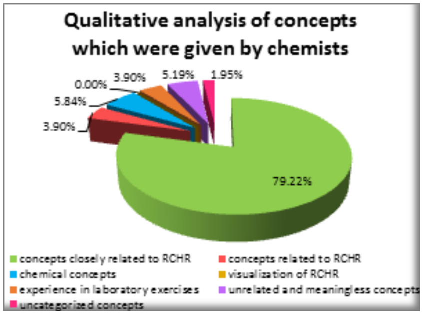


Figure 12 and 13. Qualitative analysis of the terms occurring in non-chemist and chemists

The answers of students of Master´s degree of study who study teaching of some subjects show that students have connected concept the rate of chemical reactions with reactants, products and factors affecting the rate of chemical reactions – the most temperature, then concentration and catalyst, less pressure and inhibitor and at least the surface of reactant. Almost 5% of respondents reported as a factor influencing the rate of chemical reactions volume too. Much less there occurred concepts related to the reaction mechanism - activation energy, activated complex, Collision theory, the effective collision etc. Those we expected from bachelors in the greater frequency. Other concepts that we categorized like general chemical concepts also hadn´t high frequency. There we included concepts like chemical bond, chemical reaction, chemical formula, reaction mixture, particle, molecules, chemical mass. Almost 15% of these concepts were associated with visualization of chemical reactions – effervescent, foaming, bubbling, discolouration, explosion.

In the next section of analysis, the collected data we tried to detect more deeply the differences of understanding the concept rate of chemical reaction in the group, which was composed, of students who hadn´t had chemistry at the university and in the group, which was composed of students who graduated with a chemical university education - a bachelor’s degree. We tried to identify in which aspects was affected the understanding of the concept rate of chemical reactions by bachelor preparation.

Table 2. Comparison of success of chemists and non-chemist resulting from frequency analysis

Two-level task	Parts of two level task	The relative success expressed as %	
		Chemist	Non-chemist
2-3	2	76	15
	3	94	0
4-5	4	86	90
	5	22	0
6-7	6	62	70
	7	92	71
8-9	7	81	30
	8	41	0
10-11	9	91	85
	10	68	71
12-13	11	90	50
	12	79	70
14-15	13	62	25
	14	15	0
16-17	16	14	0
	17	0	0

In the Table 2 we present relative success for individual two-level tasks so that the second item´s value is the success of students who correctly answered in the first part of two-level item. For example, in the item 2 + 3 in a group of chemists were able to write correct chemical equation of ongoing chemical reaction (thus they declared their interpretation of the equation on the symbolic level of its representation) 76% of the students. Then 94% of them were able to show understanding of the reactions to the macroscopic level of its representation. The data presented in Table 2 we will try to interpret mainly like a comparison group of chemists and non-chemist.

The data in the table 2 shows that non-chemists were able to write verbally the symbolic level of chemical reaction only in 15% of cases. From these successful students no one saw what was behind the chemical equations at the macroscopic level of representation of the chemical reaction. So the question is, what is the sense to practice continually the chemical nomenclature, which is typical for our didactic system. Neither group of students who attended university with increased interest in natural sciences these algorithms didn´t know. However, we can´t be satisfied even in the group of future teachers of chemistry. Up to the one quarter of students wasn´t able to enter a chemical equation of given chemical reaction. In spite of this, it was the typical chemical reaction that was used at all levels of education as a model reaction and from the perspective of the reaction and the stoichiometry of reaction it was an apparent and no-problem situation. It could be considered as positive that up to 94% of those who knew the symbolic representation of the reaction were able to interpret it on a macroscopic level too.

The second two-level task 4 + 5 should indicate a connection between the perception of the rate of chemical reactions and the effects of concentrations of the reactants in connection to the macroscopic representation of this effect in the specific case.

The first part of two-level task indicated the ability of respondents to correctly interpret the impact of concentration on the rate of chemical reaction. In the group of chemists, a vast majority of students (86%) correctly defined that a lower concentration of reagents caused that the chemical reactions will be slower. This statement was able to apply to the macroscopic representation correctly only 22% of them. The rest of them didn´t write the right solution. This phenomenon we consider as bad. Future teachers of chemistry can´t know the basic concepts only at the level of memory reproduction or simple application of algorithms. It is necessary that the future teachers of chemistry have the ability to switch and combine different levels of representation of chemical phenomena. According to the results of our research it achieved only every fifth future teacher of chemistry.

The situation was even worse in the group of non-chemists. Correct application of the algorithm on the impact of the concentration on the rate of chemical reaction achieved a comparable number of students (even slightly higher success of solution against a group of chemists – 90%). The second part of this two-level task failed to absolutely correct solve none of them. The results also show that the majority of respondents in both groups were able to identify the variable that caused the change of the rate of a chemical reaction but they failed to give the reason on this statement at the macroscopic expression and it stayed at microscopic and a formal level of representation. From another perspective, the observed facts can be interpreted in such a way that the results indicate a good response to the formulation of the problem and also the existence of a serious problem with the right application of declared knowledge in a wider context in less known task.

Next two-level task 6 + 7 indicated in its first part connection of the memory and algorithmic levels of mastering of the mentioned concept. In the first part of this two-level task students had identified that the change of reaction conditions in the meaning of increase in volume of reagent without changing other characteristics does not cause a change in rate of a chemical reaction. In the second part they should explain their choice. In this section, we also expected from the students that they connect together all levels of representation of the chemical situation.

The data in Table 2 shows that the group of chemists mastered the first part of two-level task at 62%. Nearly two-thirds of students thus were able to identify the changing variable and at the same time they were able to specify that this change does not effect on the change of speed of a chemical reaction. It is pleasing that almost all of them (92%) were able to explain their arguments. The situation is worse in the case if we start to analyse the level of reasoning deeper. In mentioned

92% of the accepted reasoning were included quite simple explanations, which indicate more likely the direction of reasoning as a true and full argumentations of the previous statement.

A similar situation exists in the group of non-chemists too. Correct solution of the situation described in the first part of two-level task decreased to the level of 70%. At the same time, it decreased the amount of those who were able to give a reason on its previous arguments (71%). The quality and completeness of their reasoning of solutions in the first part of two-level task were similar as in a group of chemists.

In two-level task 8 + 9 be reflected deeper understanding of the impact of the size of the reaction surface of reactant at the rate of chemical reactions. The first part should indicate the ability of students to identify which variable is changed in the described chemical situation and how to reflect changes on the rate of a It was a change in the reaction surface, but it was not "the traditionally used situation - use powdered reagent instead of pieces. In this case, there was no change in piece of reactant but the mass of the reactant was changed It was a change in the reaction surface, but it was not" the traditionally used situation - use powdered reagent instead of pieces. In this case, there was no change in piece of reactant but the mass of the reactant was changed chemical reaction. It was a change in the reaction surface, but it was not "the traditionally" used situation - use powdered reagent instead of pieces. In this case, there was no change in piece of reactant but the mass of the reactant was changed. Keeping of the basic characteristics of the reactant (same thickness of sheet) caused change of the reaction area. Students should specify the change of rate of a chemical reaction by identifying changes in mentioned variable.

In the group of chemists was successful in the first part of two-level task 81%. This result was not bad at first glance. However, the success of students in the second part of two-level task was cut in half. Only 41% of them were able to give a reason on their choice from the previous section. Thus it remains an open question, if the choice of the correct answer was really conscious or it was the result of a random fluctuation. In the group of non-chemists this two-level task proved as problematic. The success in the first part was only 41%. This information looks worse in connection with success in the second part of two-level task. Correct reasoning for choice in the first part did not provide one. It seems that the true understanding of knowledge about the impact of the size of the reaction surface of the students in both groups is not high. In the group it may be at least on some formal level, but in both groups are probably substantiated concerns about the failure of the concept rate of chemical reactions.

Two-level task 10 + 11 was oriented to identify and use the effect of temperature on the rate of chemical reactions. It was conceived more traditional, so it did not make troubles to the students to identify from the described chemical situation which variable is important and how it is reflected in the evaluation of the situation.

In the group of chemists was the success in the first part of two-level task 91%. The reasons of choice in the first part gave 68% of them. A similar result was found in group of non-chemists. The first part of two-level task was mastered successfully by 85 % of students. The reason of their choice in the second part of two-level task was given by 71% of them.

It appears that in more traditional formulation of assignments were students successful regardless of the using of knowledge from secondary level or university level of education to solve a problem. This situation we did not seen in tasks which had conceptual character. If the students are not required distant knowledge and their use in new non-traditional conditions and the context they are able to achieve good results in testing.

In two-level task 12 + 13 we worked with a chemical situation that from students required to identify the size of the reaction surface of reactant as a factor that affect the rate of chemical reaction. However, this situation has been compared to the situation in the task 8 + 9 which was formulated more traditional. We assumed therefore higher success of students in its solutions. The results give us the truth. The success in both groups increased in the first and in the second part of two-level task too. In the first part of the task in which students should identify the size of the reaction surface of reactant because it caused change in the rate of the described chemical reaction were chemists successful to 90%. Thus success compared with the two-level task 8 + 9 increased almost by 10%. A substantial increase was found in the second part of this two level task from 41% to 79%. The similar situation occurred in the group non-chemists. There was almost a dramatic improvement in order to reasoning their choice in the first part of two-level task. The value increased from 0 to 50 .

From analysis of these two-level tasks there is a conclusion that the applicability of knowledge of our students is limited. It depended on the situations in which knowledge were constructed compared to the situations in which they were tested. In remoter contexts we can state weaker preparedness of our students.

In two-level task 14 + 15 students had to declare their insight into the described situation by understanding that the limiting factor for the solution of this task is the presence of urea as inhibitor. At the same time, they had to declare the correct application of the algorithm to create conclusion about the impact of that factor at the rate of chemical reactions. In the second part of the tasks students had to explain their choices from the previous section of two level task.

Out of the group of chemists that were success in the first part of two-level task 62%, we can characterize it in regard to other two-level task as weaker achievement. This critical assessment is enhanced by the fact that its answers in the second part of two-level task were meaningfully reasoning only by 15% of students. Even in this case we can´t be sure that these 62% of students is proportion of students who actually know this aspect of the concept of the rate of chemical reactions. There it is, of course, a relatively high probability of random choice of the correct answer. Even in the case of a purposeful choice of the correct answer in the first part of two-level task without reasoning there may exist doubt about the actual understanding of mentioned concept of students.

In the group of non-chemists was situation even worse. The right solution of the first part of two-level task wrote only 25% of students. This proportion of students could be the result of random fluctuation, because the meaningful explanation in second part of task wasn´t written by anyone.

Clearly the worst situation with the success of solutions was in two-level task 16 + 17. Students had to give in the first part of two-level task symbolic writing of the rate of the chemical reaction in the form of the definition relationship. In the second part of two-level task they had to declare knowledge about the units, in which we express the value of the rate of a chemical reaction.

In the group of chemists only 14% of students gave one of the correct definition. The question is, how these students actually know mentioned concept after the completion of the basic course of chemistry and at the same time what is the level of their science and mathematical literacy. The situation is even more acute if we realize that nobody transformed the knowledge about definition to the unit of rate of a chemical reaction.

In the group of non-chemists it was still worse. The nature of understanding the concept rate of a chemical reaction into a mathematical relationship could formalize anyone. In their understanding of this chemical concept it was not found any knowledge of this relationship. The same is true for the unit of the rate of the chemical reaction. So how the scientific literacy of these students is, if the majority of them did not write anything and 15% of them wrote as the unit second?

Conclusion

If we have to summarize the results of the research in terms of the first objective, we can say that the level of mastering of the concept rate of chemical reactions was not good at the memory and symbolic level of representation too (results in items 2, 16, 17). This fact is surprising, because these aspects have traditionally in our didactic system high attention. The results also indicate significant formality and isolation of knowledge. Especially the items 16 and 17 indicate problems with mathematical and scientific literacy of students.

On the other hand, some memory-reproduce of knowledge, use an algorithm in known situation usually does not make problem to future teachers of chemistry (results of tasks 4, 8, 10, 12). Success in a similar task, which are not so directly given to a concrete knowledge or the algorithm already causes problems (results of tasks 6, 14).

Real understanding of the concept shows based on the results of research even more problematic (results of tasks 5, 9, 11, 15). Reasoning and explanation of previously declared successful knowledge does some future teachers of chemistry problems. It also appears weaker linkage of knowledge representation at different levels. There exist isolation in the understanding of the different levels of interpretation of the reporting concept.

If we have to evaluate the results of the research in terms of fulfilling the second objective, the results indicate that the bachelor preparation leaves a positive footprint in better understanding of the mentioned concept of students. Students who completed the chemical preparation only at secondary-school level, although they had similar problems as future teachers of chemistry, but they were more frequented.

The findings indicate significant deficiencies in preparation of future teachers of chemistry due to chemical fundamentals in their work. They explain the difficulties, which occur in master´s degree of study in preparing students for academic analysis and interpretation of the various parts of chemistry.

The results of this study will need to be verified in further researches, but now it is already clear, that it requires a significant change in scientific - chemical part of teacher preparation of future teachers of chemistry.

Acknowledgement

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Microwave Assisted Solvent Free Synthesis of Benzamides as School Experiment-Effect of Substituent in Benzoic Acid

Introduction

In last decades, significantly increases the interest in targeted synthesis of chemicals the required structures and properties. As a convenient way for the preparation of these substances is shown to be the use of microwaves (Loupy, 2006; Hájek, 2008).

Synthesis carried out in the presence of microwave today did not celebrate success only in the field of chemistry, but also in pharmacy, medicine and other fields. Because in recent years the company focuses not only on economic and short time more convenient ways of production and distribution of its products, but also on the environmental aspect of its activity. microwave device help populate all of these requirements are therefore increasingly used laboratory technique. Microwave synthesis without using solvents (microwave assisted, solvent-free synthesis) in the field of Green Chemistry (Varma, 1999; Kappe 2004), which includes a synthetic environment-friendly practices. In our case it is a synthesis, feasible for the needs of teaching and learning at universities and high schools (Ranu, 2009; Šauliová, 2002).

This work is not focused only on the general process of microwave synthesis, but the way its design to match the technical background of the high and especially secondary schools. The first step is the technical replacement of expensive microwave reactor considerably cheaper and more accessible microwave oven. The intention is to create a basis for laboratory exercises using the microwave oven.

The target group of the laboratory exercises are mainly university students and last but not least the students of secondary schools students in upper grades chemical or grammar schools, as further study of selected chemical, medical, pharmaceutical or other branch of science, which will use the knowledge gained from practical chemical exercise at the high school.

This work is focused on the study of the optimum reaction conditions for the reaction of octylamine with benzoic acid and its derivatives, which have different substituents in the para-position. Propduct of the reaction is the N-octylbenzamid. For comparison is also realised the reaction of aniline with formic acid and acetic acid without the use of solvents in the presence of microwave irradiation. The focus of the work is to study the influence of the substituent on the synthesis of N-oktylbenzamide and investigation of the influence of the length of the hydrocarbon chain aliphatic carboxylic acids on the formation of the corresponding N-phenylamide to promote the selection of a suitable response for teaching purposes.

Amides are substances that can be prepared many reaction procedures (Solomons, 2002; McMurry 2007). A wide range of possible response is due to the fact that the functional derivatives of carboxylic acids can be converted to each other. It follows that the more reactive derivative can be converted into less reactive. Synthesis of amides proceeds predominantly by the mechanism of acylic nucleophilic substitution. The most commonly reported reactions, which use to prepare amides are aminolysis, where the functional derivative of the carboxylic acid reacts with the amine or ammonia and form amide.

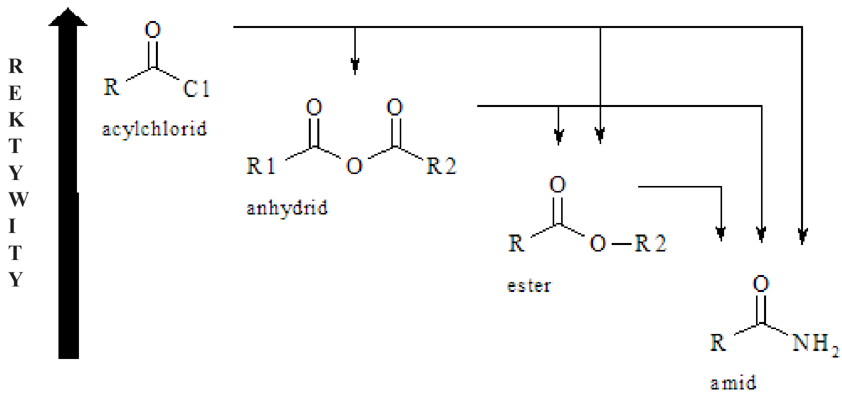
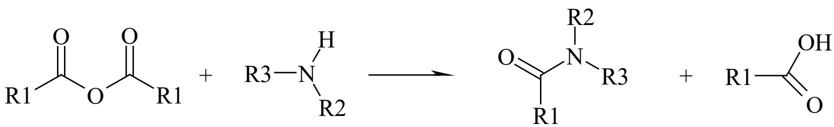


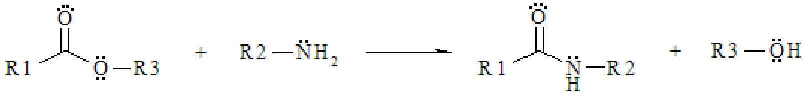
Figure 1.

From the schema implies, that the corresponding acyl chloride or other halides of carboxylic acids are most easily reactable functional derivatives. The product of the reaction of halides of carboxylic acids with ammonia, primary or secondary amines are amides, which are easily synthesized. All responses are very similar for identical reaction conditions and provide high yields.

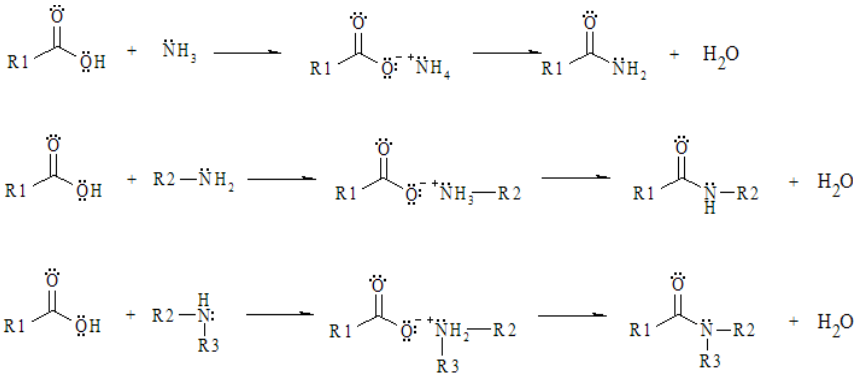
Reaction of ammonia or an amine with anhydride of carboxylic acids also occurs to the synthesis of amides. The course of this reaction is the same as for reactions with acyl halides.



Amides will also gain a reaction of the ester with ammonia or primary or secondary amine. However, this reaction has a longer time course.



Procedures emanating from halides and anhydrides of carboxylic acid have high yields, however, do not meet the requirements of the method of the Green Chemistry, both substances work are aggressively on the skin. Another way to prepare it is synthesis, when the principle of (amine or ammonia) neutralizes the carboxylic acid and this creates ammonium or ammonium salt. This is a direct reaction of the amine or ammonia with carboxylic acid. This substance to decompose when heated above 150 ° c and eliminate water molecule to form the amide. This method of synthesis are ecologically acceptable, however, the reaction is taking place for a long time. By performing the reaction



using the microwave, but you can significantly reduce the response time.

Microwave heating is dependent on the polarity of the substances involved in the reaction. The heating of the polar substances is easier than heating substances little polar. When you referred to the synthesis of amides is a requirement on the polarity of the reacting substances performed.

Preparation of amides using microwave (microwave assisted) without the use of solvents (solvent-free) engaged mainly A. Loupy and his collaborators (Perreux, Loupy & Volatron, 2002). Its publications are based on the responses of various carboxylic acids with primary amines. Our workplace has long been concerned with the use of this reaction in the university and high-school teaching of organic chemistry (Čermák, Barešová, Dostál, Myška & Kolář, 2009). Are monitored for the effects: the heating time, microwave power, the ratio of reactants and their structure (Čermák, Barešová, Myška & Kolář, 2011; Zemanová, Myška & Kolář, 2013; Barešová, 2011) on the course of reaction and its proceeds, and in relation to the principles of Green Chemistry. Proposals are then culminates with the laboratory exercises, based on synthesis of primary amides, carried out as a response without solvent in the presence of microwave radiation using commercial microwave oven.

Investigation of the influence of the structure of carboxylic acids and reaction conditions on the course of the synthesis of amides

In the synthesis of amides was give attention in particular the influence of the structure of carboxylic acids on the course of the reaction (the reaction rate, yield, selectivity, etc.). As far as the structure of the acid, it was the two model series. The first was made up of benzoic acid and its derivatives, which are characterised by different types of substituents in the position of para-. This series was made up of five substances: 1. benzoic acid, 2. p - methoxybenzoic acid 3. p-methylbenzoic acid , 4. p - chlorbenzoic acid 5. p-nitrobenzoic acid. Second model range consisted of a pair of aliphatic carboxylic acids: 1. formic acid 2. acetic acid.

According to the theory, the most reactive in the synthesis of amides are those acids, which have the largest partial positive charge on the carbon atom carboxylic groups. It is for this reason that on this carbon of carboxylic group of carboxylic acids are attack by a nucleophilic particle. The higher the partial positive charge - it is the easier nucleophilic attack. Therefore, you can reasonably expect that such acid will be easier to react, reaction speed will be higher and higher, therefore, will yield. Based on this fact, benzoic acid substitued by electronacceptor groups should find it easier to react than benzoic acid substitued electrondonor groups. In the pair of carboxylic acids (formic acid, acetic acid) the size of the partial positive charge on the carbon atom in carboxylic group are affect by alkyl group positive induction effect. From this it is clear that in formic acid should be a partial positive charge greater than in acetic acid. On the influence of the structure of carboxylic acids in the synthesis of amides may, however, adversely affect the fact that the reaction mixture is not homogenous in the melt.

Reactivity of carboxylic acids in synthesis is related to their ionization constant KA. The higher the value of the ionization constants of the stronger, and hence more reactive acid. In table 1 and table 2 shows the ionization constants of carboxylic acids, respectively, their negative logarithm-pKA.

Table 1. pKA value of benzoic acid and derivatives

Carboxylic acid	pKA
p-methoxybenzoic acid	4,47
p-methylbenzoic acid	4,34
Benzoic acid	4,20
p-chlorbenzoic acid	3,99
p-nitrobenzoic acid	3,44

Table 2. pKA value of aliphatic carboxylic acids

Carboxylic acid	pKA
Acetic acid	4,76
Formic acid	3,75

Despite the fact that the reaction takes place in the melt, where it is not guaranteed that the homogeneity of reaction mixture, has been studied correlation between the yield and the ionization constant of carboxylic acid KA (or pKA). On this occasion was demonstrated also the value of the correlation coefficient.

As far as the reaction conditions, it is necessary to mention the time of heating the reaction mixture. You can expect a short warm-up time will result in imperfect course of reaction, which results in a low yield of product. On the contrary, too long response time is favorable for increasing the yield, but is associated with risks of developing degradation products. As a result, it is necessary to optimize the time of heating the reaction mixture so that the yield is not too low, but in order to avoid decomposition products.

A factor that cannot be neglected, it is also the location of the reaction vessel on a rotating plate of microwave ovens. It is known that a rotating plate has the role, at least to a certain extent reduce the inhomogeneity of microwave field. It is entirely an individual for each device, the optimum location of the reaction vessel. The majority of places in the middle of the rotating plate, then the position of the reaction vessel is moving away from the middle. In this case, it is entirely individual matter what location the reaction container on a rotating plate is optimal.

To monitoring of the reaction course was used thin-layer chromatography. In this context, it has been examined in particular the elution agent for separation of carboxylic acids and their amides.

TLC analysis

For analysis of reaction mixture (the reaction of benzoic acid and its derivatives with octylamine) as stationary phase was used aluminium foil with a thin layer of silica gel and a luminescent indicator (Macherey-Nagel G/UV254; Alugram), and as the mobile phase was used a mixture of propan-1-ol and ammonia in the ratio of 2:1. The chromatogram of the detected in the UV chamber at wavelength of $\lambda = 254$ nm. The N-octylbenzamid and benzoic acid (and its derivatives) make quenching of luminescence, on the chromatogram of dark spots on a yelow - green background. Retardation factors of acids and amides are listed in tables no. 3 and no. 4 in terms of the analysis of the reaction products of aniline with formic acid and acetic acid (N-fenylformamid, N-fenylacetamid), as the mobile phase was used ethyl acetate, the chromatogram was again detected in the UV chamber ($\lambda = 254$ nm).

Table 3. Average number of RF (benzoic acid and derivatives /amides of benzoic acid and derivatives)

Carboxylic acid	RF	Amide of carboxylic acid	RF
p-methoxybenzoic acid	0,65	N-oktyl-p-methoxybenzamide	0,93
p-methylbenzoic acid	0,67	N-oktyl-p-methylbenzamide	0,94
Benzoic acid	0,68	N-oktylbenzamide	0,94
p-chlorbenzoic acid	0,70	N-oktyl-p-chlorbenzamide	0,94

Table 4. Average number of RF - (amides of aliphatic karboxylic acids)

Amide of aliphatic carboxylic acid	RF
N-fenylformamide	0,67
N-fenylacetamide	0,62

Process of the amide synthesis

The procedure of synthesis was based on the reaction of octylamine and benzoic acid and its derivatives with the substituent CH_3, CH_3O-, Cl-, O_2N- in para-position. Subsequently, have been carried out experiments with aliphatic organic acids (formic acid and acetic acid) with aniline.

By mixing the reactants 0.003 mole (0.38775 g) octylamine and 0.003 mole (0.36636 g) benzoic acid is obtained the starting reaction mixture. All the information about the weigh of reactants are listed in table no. 5 Both reactants were placed into a porcelain crucible, after mixing sometimes arose the highly viscous liquids or solid crystalline substances (quaternary ammonium salt). The crucible was then covered by a watch glass, inserted in a commercial microwave oven (Matrix, 800W, 2450MHz or Goddess, the performance of the

700W, 2450MHz) and then heated. Because of the leakage of aggressive substances (amines and benzoic acid) together with the steam needed heat in a microwave oven are located under the hood. After their heating the reaction mixture mostly changed colour and apparently dropped its viscosity.

Table 5 Weigh of starting materials

Name of compounds	Weigh [g]	Name of compounds	Weigh[g]
Benzoic acid	0,36636	formic acid	0,13809
p-chlorbenzoic acid	0,46971	acetic acid	0,18015
p-methylbenzoic acid	0,40845	octylamine	0,38775
p-methoxybenzoic acid	0,45645	aniline	0,27939
p-nitrobenzoic acid	0,50136		

Pure N-octylbenzamide was isolated by a procedure which removes the unreacted starting materials (benzoic acid, amine) from the reaction mixture. It was first added to the reaction mixture 25 cm^3 of chloroform, which is a mixture of dissolved. Then the entire content of this mixture was moved to the separating funnel along with 50 cm^3 2 $mol \cdot dm^{-3}$ hydrochloric acid and subsequently shaked. Then in the separating funnel separated the phase with the product from the phase with acid. This part of the procedure to ensure the removal of unreacted amine.

After first shaking and the separation of organic phase with the product we are the organic phase again placed in a separating funnel and shaked her with 50 cm^3, 5% sodium hydrogencarbonate. In this procedure, we removed the unreacted benzoic acid residues and any remains of hydrochloric acid from the previous separation.

These procedures obtained and purified product was dried using anhydrous sodium sulphate. Then, the insoluble component of a mixture was filtered and the filtrate was stripped of solvent (chloroform) by evaporation in a water bath. It was subsequently weighed and calculated the yield responses.

In the case of synthesis of amides, formed by mixing 0.003 mol aliphatic carboxylic acids with 0,003 mol aniline, was completely identical with the exception of the used eluent reagents, which in this case was ethyl acetate

Results and discussion

Investigation of the influence of the structure of carboxylic acids and reaction conditions, this is the central theme of this work. Experiments were carried out not only with benzoic acid, but especially with its derivatives with substituents in the para-position. It was necessary to confirm the theory that acid with pKA value is lower (stronger acid), will provide a higher quantity of the product, and it's for this reason that the electronacceptor substituents increases the possibility of nucleophilic attack on the carbon atom COOH group, while the electrondonor substituents reduce the possibility of nucleophilic attack.

After finding the most favourable reaction conditions are carried out experiments with the following substances: 0.003 mole benzoic acid, p-chlorbenzoic acid, p-nitrobenzoic acid, p-methoxybenzoic acid and p-methylbenzoic acid on the amount of fabric littered with 0.003 mole octylamine, and have been exposed to irradiation in the microwave field for 5, 10, 15 and 20 minutes at a medium microwave power of commercial microwave oven. The optimal location of the reaction vessel is 2 cm from the center of the rotating plate.

First reaction of benzoic acid and their derivatives with oktylaminem were examined. In the case of p-nitrobenzoic acid, the reaction was probably the thermal destruction, which was accompanied by a formation of gaseous products and a black coating in the reaction vessel. Repeated experiments have shown that under such conditions cannot be reaction of p-nitrobenzoic acid successfully realized. As regards the other acids, it were achieved satisfactory results. The highest yield, average 68.0% have reaction of p - chlorbenzoic acid with octylamine. The average yield of the product of the reaction of benzoic acid with octylamine was 63.4%. The average yield of reaction p-methylbenzoic acid with octylamine was 48.2%. Yield of reaction of p-methoxybenzoic acid with octylamine is about 44.0% .

The results of the experiments indicate a confirmation of theory related to the reactivity of carboxylic acids: stronger is a carboxylic acid, greater is yield. In this context, it has been studied the relationship between yields of amides and the pKA of carboxylic acids in identical conditions. The correlation coefficients for these dependencies reported satisfactory values (see table 6). Low correlation coefficient when the time of heating of 15 min is caused by losses for the separation of the product.

Table 6 Correlation coefficient - Average yield of amide - pKA dependence

Time [min]	Correlation coefficient
5	0,99
10	0,89
15	0,60
20	0,86

As a result, the supporting documents were designed for two educational experiments, from which they are subsequently processed tutorials for two experimental tasks. The first experimental project relates to the comparison of synthesis of amides as products of the reaction of benzoic acid, p-methylbenzoic acid and p-chlorbenzoic acid with octylamine (10 min heating, microwave power medium, reaction vessel distance 2 cm from the center of the rotating plates). The second task is under the same conditions concerned the reaction of formic acid with aniline and reaction of acetic acid with aniline. Both tasks should demonstrate the influence of the structure of carboxylic acids on progress of their reactions with amine in the sense that a stronger acid provide higher yields, in accordance with the theory nucleophilic attack on the carbon atom of carboxylic group. Experimental tasks connect the two elements in terms of learning. The first is the realization of the reactions in the presence of microwaves and without solvent, the second is the demonstration of the influence of the structure of the reactant - carboxylic acids on the yield of the reaction. Both tasks are intended for laboratory of organic chemistry and laboratory practical exercises in the didactics of chemistry on university for future teachers of chemistry. Especially the second task is then usable in practical exercises on high schools.

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Research the understanding of irreversible processes by university students

Introduction

The aim of the chapter is to introduce the readers to ideas of university students about reversible and irreversible processes. Current scientists discuss existence or non-existence of climatic changes. Another question scientists ask is whether the process of climatic change is reversible or irreversible. There are organisations monitoring the climatic processes and publishing results of these measurements on web sites. We summarise the reasons why conceptions reversible and irreversible processes are relevant for physics and for concept of environmental education. We emphasize development of a comprehensive concept of environmental physics appropriate for physics teaching in the Czech Republic.

Media

Media perform an important role in education. Scientists note in professional literature and in their interviews for media that the impact of global climate change may be serious and irreversible. This information is spread by media. Let me give three examples.

1) The Washington Post (November 2nd 2014) – "Effects of climate change 'irreversible,' U.N. panel warns in report."

2) BBC News, Science & Environment (March 31st 2014) – Climate change: The possible effects: "The impacts of global warming are likely to be 'severe, pervasive and irreversible', a major report by the UN has warned."

3) Novinky.cz (March 31st 2014): "The impacts of global warming are likely to be severe and irreversible, a major report by the UN has warned"

Irreversible change in technical practice and in other fields of human activities means an irreversible physics process (Švecová, 2015b). The opposite of the irreversible process is reversible process. Neither concept is included in the curriculum in the Czech Republic. Curriculum means the Framework Education Programme for Elementary Education with a supplement dealing with education of elementary school pupils with mild mental disabilities (hereinafter FEP EE) and the Framework Programme for Grammar Schools (hereinafter FP G).

One of the reasons is that pupils intuitively anticipate what the concept might mean and therefore their inclusion in the curriculum would be useless. But if you think of the definitions of both concepts you will find out that they are very difficult concepts and their incorrect understanding may result in an inappropriate attitude to global and climatic changes observed on the Earth. Let me give an example published in the Bulletin of the Atomic Scientists:

"When scientific experts moved the hands of the Bulletin's Doomsday Clock two minutes closer to midnight last month, calling current efforts to prevent catastrophic global warming 'entirely insufficient', some people responded that climate change is a far less disastrous threat than nuclear war because it is reversible. This is a common misconception (Stover, February 26th 2015)."

This is a serious misconception. If people think that climatic change is reversible they will probably have no reason for looking for new ways of climatic change impact mitigation. In such case attempts at increasing environmental awareness would fail. This is one of the main reasons why we consider understanding of the above mentioned concepts as fundamental for environmental education.

Materials and Methods

Pupils and secondary school students cannot encounter with concepts of reversible and irreversible processes in their school lessons in physics and mass media use these concepts of physics familiarly. The research question is: Do University students have a correct notion of what a reversible and irreversible process are? You may argue: Environmental education is part of the curriculum in the Czech Republic and it is a matter of teachers how forms choose for inclusion of environmental education in their lessons. The FEP EE came to force in the Czech Republic on the 1st September 2005. 1st September 2007 and 1st September 2013 the updated formulation of the FEP EE was applied. Since the 1st September 2016 the updated formulation of the FEP EE has applied.

Environmental Physics

Environmental physics is a quickly developing subject that should be included in environmental education. At present attempts are made to include environmental physics in physics lessons at elementary and secondary schools. Let me give a couple of examples. A book has been issued in the Czech Republic called Fyzika aktuálně: příručka nejen pro učitele (Current physics: a handbook not only for teachers) (Lepil, Halaš, Holubová, Hubeňák, & Kubínek, 2009). It is a methodological handbook for teachers explaining various issues from the area of environmental physics.

The concept of climatic literacy was introduced by (Miléř, 2012) in his theses. The author created a Draft curriculum and model activities from the 7th to the 9th forms of elementary school (Švecová, 2016).

At present a comprehensive conception of environmental physics in physics lessons at elementary and secondary schools is needed. At the same time an inquiry should be carry out to find out about the knowledge of environmental physics concepts by elementary and secondary school pupils. In our opinion the concepts reversible/irreversible process should be part of environmental physics teaching and learning.

Inquiry - Reversible/Irreversible Process

The research on understanding the concepts reversible/irreversible process was implemented in stages. The first research was performed in 2006, i.e. a year after introduction of the reform of the Czech system of education. The research took the form of a questionnaire inquiry for pupils of elementary and secondary schools. The research was followed by a teaching/learning experiment in 2008 aimed at application of the prepared scenarios into physics teaching/learning at the elementary school level (Kubincová, 2009). The teaching experiment was to find out how the pupils would react to the prepared teaching material. The scenarios underwent in-process adaptations (Švecová & Mechlová, 2014a; Švecová & Mechlová, 2014b),

The second research took place in the years 2013 and 2014 on sample university students. We were prepared the new questionnaire (Švecová, 2015b). The tested students attended elementary and secondary schools after the Czech education reform. Let me focus on the research results from 2014 (Švecová, 2015b).

The questionnaire included 12 items. The items were divided into two basic groups. The first group included processes from everyday life. The students were asked to specify whether they were reversible or irreversible processes. "An irreversible process is triggered by disruption of the thermodynamic equilibrium state of a system by an external intervention" (Mechlová & Košťál, 1999, p. 257). The second group included questions finding out about understanding of the concept of the thermodynamic equilibrium state and the ability of the students to give a correct example. The concepts are very difficult and therefore their basic definitions will follow.

Reversible and Irreversible Processes in Physics

Reversible and irreversible processes are clearly formulated concepts. They are basic concepts of thermodynamics of irreversible processes. The below definitions of reversible and irreversible processes are taken from Výkladový slovník fyziky pro základní vysokoškolský kurz (hereinafter Monolingual Dictionary of Physics), (Mechlová & Košťál, 1999). Note: The following is a translation of the original Czech text.

"Reversible process is a process that can run in both directions with the thermodynamic system going through the reverse process passing through all stages of the direct process but in the opposite sequence with the result of the system surroundings returning to the original condition. A process is considered reversible if after its run from the original condition to the target condition and back the original condition of not only the system itself, but also of all external objects in interaction with the system, is restored. The necessary and at the same time sufficient condition of a thermodynamic process's reversibility is its being a quasi static process. A process is considered irreversible if it does not meet the conditions of the reversible process. See also "irreversible process", (Mechlová & Košťál, 1999, p. 243–244).

The authors of the definition use the concept quasi static process, therefore see the below definition of quasi static process taken also from the Monolingual Dictionary of Physics, (Mechlová & Košťál, 1999, p. 243).

"Quasi static or equilibrium process is a thermodynamic process in which the system runs through a continuous series of thermodynamic equilibrium states. The state of the system changes infinitely slowly in the course of a quasi static process, i.e. the system goes through a series of infinitely close equilibrium states with its surroundings (the surrounding external environment of the system). See also "reversible process".

All real thermodynamic processes progress at a finite speed and hence they are not quasi static, these processes are called non-equilibrium processes.

However, if a real thermodynamic process progresses very slowly in comparison with the relaxation processes in the given thermodynamic system then it can be called quasi static with sufficient accuracy level," (Mechlová & Košťál, 1999, p. 243). Concepts from the thermodynamics of reversible processes are explained in detail for example by (Mechlová & Košťál, 1999; Švecová, 2015b; Kvasnica 1965).

Reversible processes are mechanical processes taking place in mechanical systems with absence of dissipative forces and permanent deformations (Ondrejka, Holec & Kmeť, 1997, p. 107). Dissipative forces take part in every mechanical process in the real world, see for example friction, air resistance etc. Hence all real processes taking part in thermodynamic systems are irreversible processes. Idealised considerations based on reversible processes lead to results only slightly different from the reality that we know from practice (Ondrejka, Holec & Kmeť, 1997, p. 107-108).

The condition of Thermodynamic equilibrium state occurs if "all external conditions in which a thermodynamic system exists (ambient temperature, external fields of force acting on the system, its volume etc.) become constant at a certain moment. Then after lapse of a certain time called the relaxation time the system gets into a state without any ongoing internal macroscopic processes and with all macroscopic characteristics of the system constant (Mechlová & Košťál, 1999, p. 237)."

Heat Engines

Heat engines work in cycles and the individual processes can be represented by a p-V diagram. As the heat engine is a motor both concepts will be used from now on. For a Definition of the heat engine is given for example (Mechlová & Košťál, 1999). Carnot cycle is the ideal circular thermodynamic cycle consisting of reversible processes only (Mechlová & Košťál, 1999, p. 247) and a "change of entropy of the whole system including the Carnot engine and its surroundings equals to zero" (Mechlová & Košťál, 1999, p. 248). This cannot be achieved with real heat engines. "The cycles of real heat engines are irreversible and are not exactly closed because the substance they work with is exhausted to the surroundings after every cycle (through the exhaust pipe) and sucked in the working cylinder (on the engine intake)" (Ondrejka, Holec & Kmeť, 1997, p. 128). Real circular processes in heat engines are irreversible for one more reason: friction takes place inside and part of the received heat is not transformed to useful work but to inner energy (Ondrejka, Holec & Kmeť, 1997, p. 128). What follows from these conclusions is that even if a process can be expressed by a p-V diagram, it need not necessarily be a reversible process. To approximate a real cycle to the Carnot cycle in the sense of a reversible process it would have to progress very slowly. In technical practice this is not possible because a slow heat engine would not be usable in practice (Ondrejka, Holec & Kmeť, 1997, p. 128).

Research Results

The text above shows basic definitions of reversible and irreversible processes in physics. These definitions were used as the assumptions for preparation of the questionnaire which was given to university students to fill out in 2013. Subsequently the questionnaire was adapted and submitted to university students in 2014, too. The following part sums up research results from 2014 (Švecová, 2015b). In 2014 the research sample included 69 students of science. The cohort included 52 female and 17 male students.

Questionnaire Inquiry Results - Reversible and Irreversible Processes

The research pointed out misconceptions of reversible and irreversible processes in the answers of university students. Student ideas of reversible and irreversible processes differed from the definitions from physics presented above. You can see a certain analogy with the concept of work as this concept is used in "everyday language" and the definition of mechanical work used in physics. The misconceptions of university students pointed out to what needs to be emphasized in physics lessons (Švecová, 2015a).

Most of the secondary school pupils were able to give an example of an irreversible process.

Some misconceptions concerning reversible processes found in the answers of university students are followed.

- In total 64 % of the students answered: "A refrigerator is a heat engine working in cycles. The cycles consist of reversible processes" (misconception) (Švecová, 2015b, p. 33)

- In total 37 % students answered that recycling of an old car is a reversible process (misconception) (Švecová, 2015b, p. 33).

- In total 77 % inquired students answered that used paper recycling is a reversible process (misconception) (Švecová, 2015b, p. 33).

- In total 47 % students considered face-lifting of eyelids a reversible process (misconception) (Švecová, 2015b, p. 33).

- In total 45 % out of the 69 inquired university students considered climatic changes observed on the Earth to be reversible processes; 55 % of the 69 respondents saw climatic changes on the Earth as irreversible". (Švecová, 2015b, p. 34).

- In total a mere 7 % of the students presented a correct idea of the reversible process, 56 % answering with an incorrect idea and 37 % respondents not answering at all.

- In total 55 % of the respondents presented a correct understanding of a irreversible process while 4 % had an incorrect idea and 41 % of the students were unable to answer.

The multiple choice questions were given correct answers by more respondents than the open questions where the answer was to be formulated by the respondent as a free text. Our results correspond to the results of PISA 2012 and TIMSS 2007 research where the latter items recorded lower numbers of responses (Švecová, 2015b, p. 29).

The explanations may be that the students did not know the answer, did not want to give an incorrect answer where they were not sure or did not see the relevance of the questions in the questionnaire.

Questionnaire Inquiry Results - Thermodynamic Equilibrium, Equilibrium State

An irreversible process follows disruption of the condition of thermodynamic equilibrium of a system by external interference as was mentioned in the definition above. The questionnaire included questions trying to find out how students understood the condition of thermodynamic equilibrium. Thermodynamic equilibrium is connected with temperature and with temperature measurement. Below please find two tasks and students' answers concerning temperature measurement. The examples are followed by a survey of the numbers of correct answers to the questions on examples of thermodynamic equilibrium conditions and equilibrium state in nature.

Object Temperature

As follows from the zero thermodynamic principle: The temperature of all systems in a equilibrium thermodynamic state in relation to each other is the same.

Question:

Constant temperature of 21 °C is maintained in a room. A steel pipe and a wooden board are placed in the room for 48 hours. What is the temperature of the steel pipe and the wooden board (Švecová, 2015b, p. 26)?

a) The steel pipe is colder than the wooden board.

b) The wooden board is colder than the steel pipe.

c) The temperature cannot be determined without its measurement by a thermometer.

d) The temperature of both objects is the same and equals the room temperature.

Table 1. Student answers

Answer variants	a	b	c	d	Other answer	No answer
Relative frequencies of student answers	25 %	21 %	4 %	37 %	3 %	9 %

The results showed that only 37 % of the respondents answered correctly that the temperature of both objects is the same. In total 25 % of the respondents answered that the temperature of the steel pipe is lower than the temperature of the wooden board (misconception). In addition 21 % of the respondents answered that the temperature of the wooden board would be lower than the temperature of the steel pipe (misconception). In total 37 % of the respondents answered that the temperature must be measured with a thermometer.

The temperature can be specified without measurement. The question says that constant temperature of 21 °C is maintained in the room and that both objects are placed in the room for 48 hours. Considering the specific heat capacity of steel approximately from $c_{20} = 0{,}45 \frac{\mathrm{kJ}}{\mathrm{kg \cdot K}}$ to $c_{20} = 0{,}500 \frac{\mathrm{kJ}}{\mathrm{kg \cdot K}}$ and of wood $c = 1{,}6 \frac{\mathrm{kJ}}{\mathrm{kg \cdot K}}$ the specified time is sufficient for both objects to establish thermodynamic equilibrium with their surroundings. The answer saying that the temperature must always be measured by a thermometer would apply to living organisms or to ventilated rooms.

Different temperatures might then be measured for example with a thermal camera. Emissivity must be set correctly in the thermal camera for that purpose. And further every measuring instrument measures within a certain tolerance, the boundary error.

Comparison of Temperatures on Human Body Surface and Inside Human Body

Human body temperature measurement is physical measurement which is part of human experience from early childhood. The item was selected as motivating for filling out the questionnaire.

Question:

Is the temperature on the human body surface different from the temperature inside the human body? Select the answer corresponding to your opinion (Švecová, 2015b, p. 27).

a) No, it is not. The temperature measured on the human body surface is the same as the temperature inside the human body.

b) Yes, it is. Human body surface temperature is lower than the temperature inside the human body.

c) Yes, it is. Human body surface temperature is higher than the temperature inside the human body.

d) Other answer:

Table 2. Student answers: Comparison of Temperatures on the Human Body Surface and Inside the Human Body

Answer variants	a	b	c	d	No answer
Relative frequencies of student answers	9 %	77 %	7 %	4 %	3 %

In total 77 % of the responding students correctly answered that the surface temperature of the human body is lower than its temperature inside. In total 9 % of students selected the answer that the temperatures were the same and 7 % of students answered that the temperatures differed but chose the opposite relation: Human body surface temperature is higher than the temperature inside the human body. Another answer was provided by 4 % of the respondents. Three percent of the respondents did not fill the item out.

Example of Thermodynamic Equilibrium in Nature

We further tried to find out whether the respondents would be able to give a correct example of natural thermodynamic equilibrium, an example of equilibrium in nature. The notions of equilibrium state and thermodynamic equilibrium mean the same state.

- In total 16 % of respondents provided a correct example of thermodynamic equilibrium in nature, while 7 % were represented by incorrect answers and 77 % by no answer.
- In total 24 % of respondents gave a correct example of equilibrium state in nature, while 12 % of respondents provided incorrect answers and 64 % did not answer at all (Švecová, 2015b).

A high percentage of the respondents did not answer these questions at all. This again confirmed the observation that open questions had a lower percentage of answers in comparison to multiple choice questions.

Questionnaire Inquiry Results - Conclusion

The inquiry respondents included university students of science – biology, chemistry, and biophysics. This means specialists in the given field. It needs to be noted, though, that the survey was implemented at the beginning of their studies, not at the end. The results of the research cannot be used for drawing conclusions about whether and how the university is able to provide knowledge in this area to the students. This is just input data informing that if you want people to understand consequences of the ongoing global changes they must be able to understand the concepts of reversible processes and irreversible processes in the context of global warming and the understanding must come in the course of their elementary and secondary school attendance.

Conclusions and Implications

Scientists and various international organisations note that the impact of the global climate changes will probably be serious and irreversible. Irreversible change is an irreversible process in physics. Reversible and irreversible processes are concepts used in physics which elementary and secondary school pupils are not introduced to in their physics lessons. Opponents may argue that environmental education is part of the curriculum in the Czech Republic after the reform. But the above described research was performed with university students who already attended school after the reform.

And yet the results pointed out to certain misconceptions. Pupils of elementary and secondary school who took part in the research considered repeating processes reversible. That is a misconception. Circular processes need not be reversible processes. Not only must the system return to its original condition but also its environment. For example 77 % of the respondents considered paper recycling a reversible process (misconception). The research results cannot be applied to the whole population as the inquired sample was small.

As a result of the survey we suggest inclusion of introduction to the concept of irreversible process to the syllabus of the subject of physics at elementary schools. The definition should be accompanied by practical examples. Elementary as well as secondary school students were able to give an example of an irreversible process. Focus should be on current data published by international organisations for elementary and secondary school pupils.

The syllabus of the subject of physics for secondary schools should include the concepts of reversible processes and irreversible processes. The definition should be accompanied by practical examples. Further related concepts should be included as well, such as ice melting, changes of surface temperature on the Earth, changed concentrations of carbon dioxide in the atmosphere etc.

The basic task is formation of a comprehensive concept of environmental physics applicable in elementary and secondary school curricula. The concept should interconnect physics, chemistry, biology, geography, modern technologies and media. Current data from international organisations should be incorporated.

Tools should be created for verification of understanding of these concepts on larger population samples. An expert discussion on this theme should be initiated.

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Changes in the Polish education system and professional-demographic profile of teachers gaining qualifications at the Pedagogical University (UP) to teach Natural Sciences from 2000 to 2016

Introduction:

The specificity of the teaching profession requires not only thorough preparation to it in the course of study but also continuous training and improvement after its completion, during work. (Piróg & Jania, 2013). The need for such actions is intensified by social and economic changes, technological progress and the reform of the education system. It considerably broadened the scope of tasks to be performed and currently a teacher of a school subject / educator should perform a number of other roles, he should be ie .: a guide, a manager, a diagnostician, a creator, or a mediator (Buchcic, 2012). Enhancement of behavioral problems induces the need for a permanent development of psycho-pedagogical competence (Osuch, 2010). Moreover, the teacher in his work has a duty to shape students' beliefs about the need for learning throughout life and therefore he should serve as an example of lifelong learning. This creates a new challenge for teachers at all levels of education, and even more clearly puts them in front of the necessity of permanent professional training, to be able to attractively and effectively implement the objectives of teaching and education. This thesis seems to be confirmed by results of the diagnosis, made under the TALIS program, which indicates that as many as 97% of teachers working in lower secondary schools have declared using a variety of formal and informal forms of education and training (Piróg, 2012).

As shown by the studies conducted among teachers in Malopolska Province, the most frequently chosen forms of education are postgraduate studies, equipping them with new qualifications[1] (Kosiba, 2012; Piróg & Jania, 2013). This trend is also confirmed by ORE national research, which indicates that in the school year 2014/15 almost 45,8% of still learning teachers in Poland attended in postgraduate studies (Rachubka, 2015).

[1] Every fourth geography teacher was during or completed postgraduate studies. They also planned to make further efforts to improve and further training. As many as 81% of respondents took into account the start of postgraduate studies in order to obtain the qualification to teach another subject.

Objectives, subject of study and research methods

The main objective of this article is to analyze changes in the number, age structure, gender and territorial origin of teachers, who in the years 2000-2016 at the Pedagogical University of Cracow gained the qualification entitling them to teach Natural Sciences. The concomitant aim is the discussion on starting the reform of the education system in Poland and its the consequences for those teachers, whose employment is based on teaching Natural Sciences in elementary school. The method of analyzing documents was used for data collection, ie. personal questionnaires of postgraduate students. These included complete information to achieve objectives of conducted research. Each questionnaire allowed to obtain the following information: age of teachers, gender, year of commencement and completion of studies, education (town, university, faculty), residence, place of study conducted by UP[2].

Data was entered into the prepared base and then subjected to quantitative, qualitative and spatial analysis.

Qualifying postgraduate studies for teachers - analysis of factors

The pedeutological and psychological literature usually indicate four groups of factors that affect teachers' decision to start qualifying postgraduate studies. These include socio-economic, systemic, institutional and individual factors (Błaszkiewicz, 2001; Skarżyńska-Gasparski, 2001; Barnett, 2004; Higgitt 2012; Spronken-Smith, 2013).

The group of socio-economic factors highlights the importance of the situation in the educational labor market which remains in a close relationship with demographic trends. The decrease in the number of students brings closing educational institutions and branch offices resulting in job cuts for teachers. And so - according to GUS (Central Statistical Office) data - for example, school year 2013/2014 started in Poland, with 5916 branches, 1259 schools and 8145 teachers employed less than in the previous year. In this situation, the risk of loss of employment and increased competition in the labor market, often mobilize teachers start studies giving them additional skills and increase their chances on the market (Kołodziejczyk & Polak, 2011).

[2] Pedagogical University conducted Natural Sciences postgraduate studies in Krakow and long distance centers in Tarnów, Myślenice, Częstochowa, Bielsko-Biała, Nowy Sącz and Rybnik.

Table 1. Factors affecting teachers' decision to start qualifying postgraduate studies

Socio-economic factors: • unemployment rate (total) • unemployment rate (in the profession) • the attractiveness of the profession (financial; non-financial) • technological progress • demographic situation	**Institutional actors** • the offer of studies • organization and the price of studies • the prestige of the university • location of the university
Systemic factors: • the structure of subjects • the hourly dimension of individual subjects • limits on class size • the dimension of time job • retirement age • rules of professional advancement • sources of financing improvement	**Individual factors:** • internal motivations (intellectual development, meeting own interests, aspirations to be a master in own's profession) • external motivations (maintaining employment, strengthening the professional position, remuneration, the recommendation of management)

Source: own study based on Barnett, 2004; Higgitt 2012; Spronken-Smith, 2013.

Among systemic conditions - those on the structure of education, taken at the national level, seems to be the most important. Reforms of the education system bring not only structural and program changes, but usually, result in the need for further training of teachers so that they can either learn new school subjects or retrain in a situation where previously taught subject has been reduced in the number of hours or stages of learning. One of these subjects were in 1999 Natural Sciences in elementary school. By the time educational labor market filled with graduates of teacher training, which offered students a specialization in the field of Natural Sciences, people interested in teaching this subject could lead it formally only by graduating qualifying studies in this field. This interest in the possibility of teaching Natural Sciences was intensified by the phenomenon of declining student populations in schools, which threatened with difficulties in filling teaching load and even job loss. This situation mobilized and continues to be an important stimulus for the large community of teachers to acquire qualifications to teach at least two and often a larger number of school subjects.

Essential for taking postgraduate studies (giving additional qualifications) are formal rules of professional advancement and accepted recruitment procedures. If the proceedings promote this type of courses, usually they imply growth of interest in them among teachers. Also, increasing the teaching load and extending the retirement age are factors that induce the need for formal confirmation of new professional qualifications

Another factor launching the decision about starting postgraduate studies by teachers is an offer presented by the universities. The substantive scope, duration, the organization of conferences, tuition fees and additional costs related to the distance of the university from teachers' homes (travel, accommodation) as well as the prestige and brand of the university, are those elements which in the field of institutional factors may influence the decision to participate in such studies.

Finally, a very important reason for choosing this path of improvement may individual autotelic or instrumental motives of every man. For some of these people, the reason is the need for self-development, the experience of intellectual adventure. Teachers are ambitious people who are aware of the need for lifelong education, who want to improve their skills and become masters in their profession for their own inner satisfaction. They also want to strengthen their professional position, or to receive a higher salary.

All these factors are - with different intensity - reflected in the characteristics of quantitative and qualitative structures of people taking postgraduate qualification. In the light of previous studies, we can notice the regularity, **that the greater the difficulties teachers have in obtaining and keeping a job in education, the more intense training process and more diverse demographic and professional profile of people taking up this activity**.

Natural Sciences postgraduate studies at the Pedagogical University of Cracow - graduates' profiles analysis

The reform of the education system in Poland, which began in 1999, resulted in the introduction of Natural Sciences subject on the second stage of education in primary school. This triggered a large population of teachers, especially from old primary schools, willing to gain qualifications to teach the subject.

Qualifying post-graduate Natural Sciences studies have been carried out since 1999 by UP Faculty of Geography and Biology in Krakow and have been realized Institute of Geography, Institute of Biology and long distance learning centers.

1962 people, including 1813 women (92.4%) and 149 men (7.6%), completed qualifying post-graduate Natural Sciences studies at Pedagogical University of Cracow from 2000 to 2015. For comparison, in Poland, in the school year 2014/2015, 19889 teachers of Natural Sciences were employed, including 17929 women (Rachubka, 2015), which accounted for 90.1% of the Natural Sciences' teachers population. In addition, it is worth noting that during the school year 2014/2015 the number of Natural Sciences teachers was higher than both the number of employed biology (15900) and geography teachers (15308). To obtain complete data for science subjects: there were 14938 chemistry teachers and 14701 physics teachers employed (Rachubka, 2015). These figures show how large is the current population of teachers of Natural Sciences in relation to teachers of all science subjects (biology, geography, physics, and chemistry) taught in general education schools, and so both gymnasium and lyceum. Such large occupational group as well as incurred huge costs of education, and basically training and retraining of such a large group of teachers should not be missed in planned new reform of the education system in Poland.

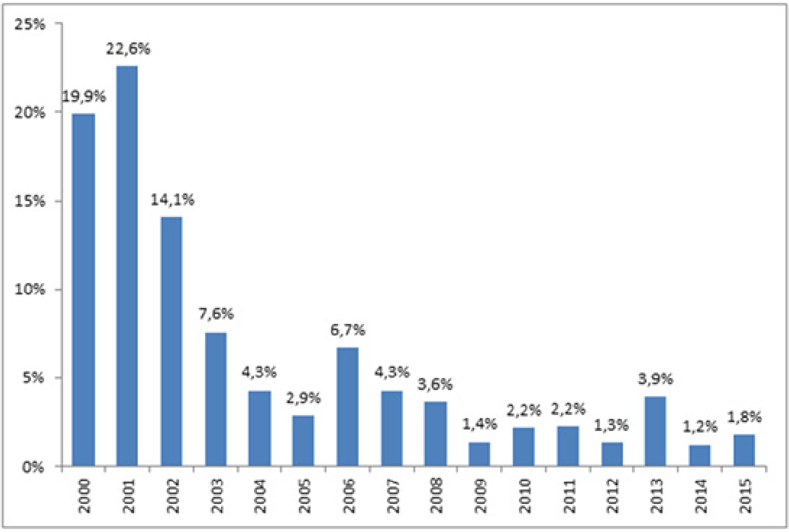

Figure 1. Graduates of Natural Sciences postgraduate studies in different years
Source: author's own study

Based on the obtained data it can be concluded that as many as nearly 57% of graduates gained the qualification in the first three years of post-graduate studies from Natural Sciences (2000-2002). It is worth noting that an important factor supporting the teacher's a decision on further education was the possibility of receiving a grant from school authorities. In the vast majority of the early years of the reform, teachers obtained such funding for postgraduate qualification and even, in some cases, it was very beneficial and up to 100% of all the costs.

An important factor to undertake postgraduate studies, as already signaled in the previous section, is the offer of higher education institutions (type of study, the price of study - tuition fees, travel costs, possible accommodation, as well as the program of study and a favorable schedule, selection of teachers, as well as opinions of university). As previously mentioned, the qualifying postgraduate studies from Natural Sciences were carried out regularly in Krakow (every year) and casually in the selected long distance centers, which was very beneficial for teachers who live in distant towns, often in peripheral areas, regions and have limited access to university offer. In this case, the university – the Pedagogical University of Cracow - went "outside" with this offer, what immediately met with great interest and a positive opinion, because it did not generate additional costs for students. Proper selection of experienced staff and a favorable schedule, like no classes on Fridays in some long distance centers or earlier terminated classes on Sundays, encourage students to take up the UP offer of study. The positive opinion of the university since many years caused that up to 43% of postgraduate students of Natural Sciences are former graduates of the Higher School of Pedagogy in Cracow (WSP) and Pedagogical Academy (AP) – currently called the Pedagogical University of Cracow. Almost 10% of postgraduate students are graduates of the Jagiellonian University, less than 9% come from the Silesian University.

Among the postgraduate students the inhabitants of the Malopolska Province dominate (almost 70%), followed by the Podkarpacie Province (14%), the Silesia Province (13%), Świętokrzyskie Province (only 2%), which basically corresponds to the places of location of postgraduate studies (Kraków, Tarnów Limanowa, Nowy Sącz, Częstochowa, Bielsko-Biała, Rybnik) and only partly coincides with the distribution of students and graduates of the Pedagogical University.

Teachers are ambitious people who are aware of the need for lifelong education. Therefore they wish to refresh their knowledge, competence and decide to undertake postgraduate studies. This form of training is the most popular, also because of its importance in the promotion procedure from 1999 reform. Obtaining a degree appointed teacher usually provides a contract of indefinite duration and definitely strengthens the position of a teacher in the school. Therefore, postgraduate qualification from Natural Sciences gave many teachers such an opportunity.

Over the analyzed time period, the most numerous group of teachers undertaking postgraduate studies from Natural Sciences were graduates of the faculties of education - teachers with specializations: integrated, pre-school and early school education. The high interest in taking the studies by this group of teachers is the result of their interest in working in primary school as not only teachers in classes 1-3 but also in classes 4-6.

It is also important to remember about the demographic decline for the primary school and the reduction of classes, including the presence of many schools having only one class from the particular year (especially in small towns). Over the next 5-20 years, Poland will belong to the European countries with low fertility rates, and consequently, the size of the population aged 6-14 years will fall by about 15-16%. In the coming years the population aged 9-11 years (classes 4-6) - students having Natural Sciences classes will be maintained at a similar level to the present one. Although since 2014 the number of children in older grades of primary school will continue to grow, after 2020 the number of children enrolled in primary education will be gradually decreased. This fall will be the deepest in the early 30s of this century.

Table 2. Natural Sciences postgraduate studies graduates by selected fields of study

The direction of completed studies	Number of graduates	Percentage share
Pedagogy (Integrated, Pre-School and Early School Education)	377	19,2
Geography	372	19,0
Biology	323	16,5
Agriculture (agricultural economics, agrobiology)	78	4,0
History	69	3,5
Physical education	66	3,4
Mathematics	51	2,6
Gardening	46	2,3
Zootechnics	40	2,0
Economy	31	1,6
Chemistry	30	1,5
Technique (with computer sciences)	25	1,3
Theology	25	1,3
Russian, German, English and Roman Philology	24	1,2
Polish Philology	23	1,2

Source: author's own study

Another very large group of students are the teachers of geography (19%) and biology (16.5%), which seems understandable due to their interest in nature and desire (or maybe even the need) to preserve jobs after the "removal" of geography and biology from primary school to gymnasium. Especially teachers of municipal schools, where gymnasia were created, were looking for employment in elementary school, teaching Natural Sciences, to supplement their job time.

Natural Sciences postgraduate studies also aroused significant interest among history, physical education, and mathematics teachers. In this case, the main motive was to keep the current place of employment (by supplementing it with new hours of job time) and getting another promotion degree. Studies indicate that in recent years there has also been some interest in Natural Sciences postgraduate studies among foreign language teachers, which indicates a slow but steadily shrinking educational labor market, also for philologists. This trend seems to illustrate the growing difficulties not only in recruiting but also in keeping the job in education, which currently applies to specialists of almost all subjects. Secondly, it demonstrates the increasing competitiveness on the labor market in general, not only in education, because for many years, philology, and especially the English philology and German philology graduates could easily count on interesting and varied employment offers.

Noteworthy is the presence of agricultural graduates (a total of approx. 9% of the audience) among Natural Sciences postgraduate students. Such a solution will be linked with their natural interests (agriculture, horticulture, animal husbandry), as well as the desire to work in school and resettle professional profile. Such a change is also connected with the need to obtain additional allowances by a teaching course or postgraduate studies. In most cases, such certificates of successfully completed course postgraduate students included in their documentation.

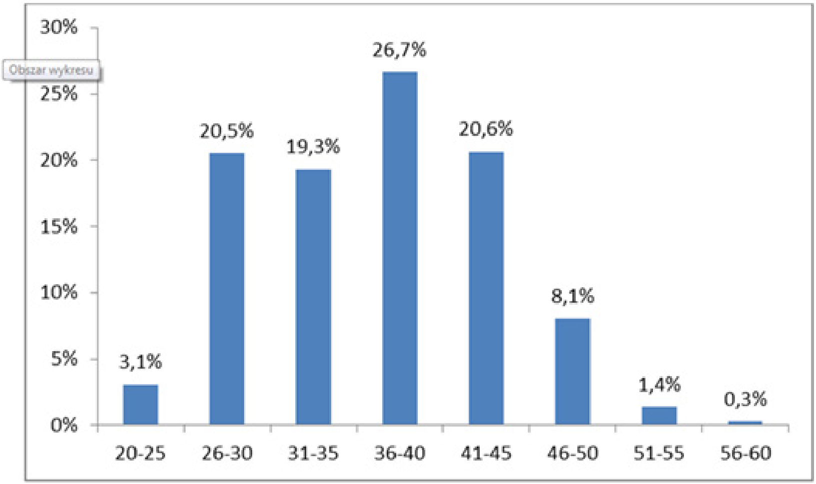

Figure 3. Age structure of Natural Sciences postgraduate studies graduates

Source: author's own study

The largest age group among the graduates were teachers with many years of work experience aged 36-40 years (26.7%) and 41-45 years (20.6%). This shows that the people who run the risk of losing their jobs in schools (no teaching load, etc.) often do not see for themselves any other alternatives in the labor market. Teachers think stereotypically about themselves and their competence, and even if they are tired of working in a school, they decide to undertake postgraduate studies to maintain employment in education and do not start looking for a job in other professions. It should also be noted that the number of teachers after 46 years (and older) was approx. 10%, which proves their precarious employment situation, despite such a large professional experience.

Unfortunately, the unstable situation on the teachers' labor market is not strengthened by the prestige of the profession, which is quite low, and the competencies – usually preparing only for this type of work. This is another incentive for attempts to remain in education, instead of changing job. Teachers decide to undertake postgraduate studies in order to keep their jobs and also to improve their competence in the field of information and communication technologies (ICT). These are essential in ensuring quality education in the current conditions.

In recent years we notice more Natural Sciences postgraduate studies graduates aged 26-30 years old (a total of approx. 20%), and even 20-25-year-old graduates of bachelor studies immediately undertaking postgraduate qualification. This solution shows the willingness of today's students to the process of training and acceptance of an already formed model of lifelong learning, which contributes to the acquisition of additional competencies.

Summary

The specificity of the contemporary educational labor market, implemented reforms, new challenges for teachers, the risk of job losses in a situation of decreasing number of children and adolescents under the age of compulsory school and the nature of the profession, cause that teachers need to intensively take actions for further education and training.

A thorough analysis of the dynamics of change of specific attributes of the studied population seems to entitle to the conclusion that the structure of these teachers clearly illustrates each of changes mentioned. It also shows (like the pyramid of age and sex shows demographic changes) all changes in Polish schools and educational labor market, both positively motivating to activity, indicating openness to training, gaining successive degrees of career development and acquisition of new skills, including the communication and information, as well as those resulting from the need to study in order to keep jobs.

The collected material shows that a considerable influence on the involvement of teachers is a critical and uncertain position of educators, geographers, biologists or teachers of other subjects and the threat of job loss situation for those presenting qualifications to teach only one school subject. According to the research, it should be stated that currently the intense commitment of teachers, mainly in forms of training facilitating the acquisition and rights to teach another school subjects, seems inevitable and most effective way to adapt to the multiple challenges facing educational labor market.

According to growing difficulties of all teachers on the job market, we should expect an even greater commitment of this group to improvement and training. It is very important to take action, both in the area of building a high-quality offer corresponding to the needs of teachers and in supporting them in that regard at the central level.

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Case Studies of Think Aloud Research in Science Education

Introduction

Education research, including science education research, has many different kinds, some of which are privileged by being preferentially funded. This paper includes, in part, a social justice lens to critique these kinds, especially in terms of the role and power of the participants. Of course, such research is highly influenced by research in other areas, not least that which takes place in the medical field. The latter is dominated by Randomised Controlled Trials but is also dominated by a positivist atmosphere, in which the participants are simply data sources in a research programme where the researchers are in control, experts with very strong power over the whole process. Even those in the control sample, where the intervention is presumed not to be as good from the start, are aliens in the exploration, hardly involved, and certainly given no authority. It is a system that has the greatest gap between the researchers and the participants while acknowledging that the system will have substantial impact on them, in some cases, life-determining. Modern medical research, in the Randomised Controlled Trails community, is one where the corporations involved hold the trump cards, always.

At one extreme, this corporate medical model, supported by the learned scientific societies as their champions, occupies part of the research space in education. The Evidence Based Teaching web site (www 1.) claims 'Like Evidence-Based Medicine, Evidence-Based Teaching uses methods which have been thoroughly tested and proven to be effective.' They also treat teachers with some lack of respect for their skills in surveying the research literature: 'While there is a lot of good evidence available, much of it is hidden in academic journals and books. 'The Evidence-Based Teacher's Toolkit' presents this evidence in accessible and practical ways for teachers.' This latter quote also fails to recognise efforts by education researchers to disseminate their work, seeing academic journals and books as the tools used by researchers to hide their findings. The Evidence-Based web site also notes: 'Using the latest research, this video explains, in a jargon-free and accessible way, how the brain learns, and why some students find learning difficult.' Implying that professional discourse is 'jargon' and that teachers need mediators to make this accessible. They are at pains to show that their work is based on 'real lessons', perhaps implying that education research is based on something else, maybe 'unreal lessons'. Naturally, for teachers to access this mediated material, there is a substantial price tag to match. The Evidence-based Teachers' Network (www 2.) sets out clearly what counts as good and poor evidence (the latter first given by the web site):

Poor evidence

Classroom experiments which have:

- a very short time scale
- few students involved
- no control group (to compare)
- lessons taught by the experimenters
- only one teacher involved

Sources of good evidence

Classroom experiments – conducted with control groups.
Educational neuroscience – studying how the brain learns

Note here the caricature of extremes in the case of poor evidence, with the privileging of Randomised Controlled Trials, validated by some 'educational neuroscience'. The rhetoric is very strong.

Finally, in this section, I should note the official UK government report (www 3.) which, rather unsurprisingly since it was commissioned by the Evidence-Based Teaching Network giving funding to academic colleagues to ensure that the message of such positivist education research is both adopted and disseminated.

Much is discussed in the science education research literature recently about the value of Randomised Control Trials (RCTs) (Chalmers et al, 1981), commonly used in analytical medical research. In England it has been proposed by the 2010 13 Coalition government as the means by which evidence-based research will form the basis for a new direction in research (proposal terminology, see www 4.). Acceptance of this approach, by the Wellcome Foundation for example. and in guidance from The National Foundation for Education Research (www 5.) is based mainly on analytical medical research and promoted by Ben Goldacre, an expert in such methods, (www 6.). However, education is not medicine, and education research is not medical research. There are many challenges to simply adopting RCTs as a gold standard in education research:

1. RCTs accept that variables can easily be separated, distinguished and assessed. The analytical approach of much modern medicine supports such a view, while modern education adopts a more holistic attitude, intertwined with the fuzziness of much of human learning.

2. RCTs place the researchers as power privileged, treating participants simply as data sources. While such a power relationship can be ethical, it is suspect in terms of social justice. It adopts the principle that researchers are experts, and that participants are not, and therefore not able to make meaningful comment on the interventions proposed.

3. RCT surveys, questionnaires and interviews emanate from the researchers, and not at all from the participants, and are thus the product of the unequal power relationship.

4. Analysis of RCTs then continues to be in the hands of the researchers, often through statistical methods that further alienate the participants.

5. Interpretation of RCT analysis lies firmly in the hands of the RCT researchers, and rarely, if ever, in the hands of the participants.

6. RCT reports complete the separation of researchers and participants, often being written in expert and dense language, and published in inaccessible professional journals. It is rare for a version of a report to be written in lay language.

7. Finally, given their huge costs, RCTs can only be undertaken by fairly large, or large, research groups, making it nearly impossible for individual researchers, and especially schoolteachers, to conduct.

A major impact that led to the present strong focus on RCTs was the invitation of Michael Gove, the UK Secretary of State for Education to Ben Goldacre, a populiser of RCTs in medical research. He quotes on his web site www 7.

Building evidence into education

Dr Ben Goldacre will set out today how teachers in England have the chance to make teaching a truly evidence-based profession.

Education Secretary Michael Gove asked Dr Goldacre to examine the role of evidence in the education sector.

In a paper to be presented at Bethnal Green Academy, Dr Goldacre will say today that research into "which approaches work best" should be embedded as seamlessly as possible into everyday activity in education.

High-quality research into what works best can improve outcomes, benefitting pupils and increasing teachers' independence. But Dr Goldacre's recommendations go beyond simply running more "randomised trials", or individual research projects. Drawing on comparisons between education and medicine, he said medicine had "leapt forward" by creating a simple infrastructure that supports evidence-based practice, making it easy and commonplace.

Dr Goldacre says that:
– research on what works best should be a routine part of life in education
– teachers should be empowered to participate in research
– myths about randomised trials in education should be addressed, removing barriers to research
– the results of research should be disseminated more efficiently

– resources on research should be available to teachers, enabling them to be critical and thoughtful consumers of evidence

– barriers between teachers and researchers should be removed

– teachers should be driving the research agenda, by identifying questions that need to be answered.

In some of the highest performing education jurisdictions, including Singapore, he explained: "it is almost impossible to rise up the career ladder of teaching, without also doing some work on research in education."

Dr Goldacre said:

"This is not about telling teachers what to do. It is in fact quite the opposite. This is about empowering teachers to make independent, informed decisions about what works, by generating good quality evidence, and using it thoughtfully."

"The gains here are potentially huge. Medicine has leapt forward with evidence-based practice. Teachers have the same opportunity to leap forwards and become a truly evidence-based profession. This is a huge prize, waiting to be claimed by teachers."

The trail to preferring RCTs in education research is out in the open.

There are other criticisms of this recent move to prioritise funding of RCTs (see e.g. www 8.) However, access to funding is a big influence, as the growth of the Education Endowment Foundation attests. For an example of its work on primary talking in science, see its web site (www 9.) that is clearly based on an RCT. RCTs are best placed to search for analytical correlations between clear and unambiguous data. In practice there are some other problems that arise:

1. Control groups must be, at least, similar, if not identical. In practice this is assured on the basis of past assessments, such as examination or test results gained for a different purpose. It is then rare for the groups to be assured for age distribution similarity, although gender is usually one of the variables controlled. Social class distribution is difficult given the issue of confidentiality of personal home data, and proxy data, such as free school meals, or the number of books available at home, have to substitute, often without any further validation.

2. One composite variable is the teacher, the pedagogy used, and teacher beliefs and motivation. Much of the research focuses on the learner (student) outcomes, and takes little notice of difference in this composite variable. Also inherent in this variable is experience and expertise of the teacher.

3. Cause and effect are very difficult to extract from correlational evidence (see e.g. Beebee et al, 2012) We can only be sure of the correlations in the circumstances and specific contexts of the data set.

Some of us are interested in the changes going on in the mind as learning takes place. I am not convinced by the neuroscientists who claim that MRI imaging is the way forward (as though synapse bursts represent learning), nor am I convinced by much of the cognitive psychologists' output, often conducted on undergraduate psychology students by postgraduate psychology students! The Think Aloud (TA) method which we have used in the PALAVA teacher researcher group for some substantial time now, is one we recognize that gets closer to exploring the changes that take place in learning. Perhaps even more significantly, the process of TA research seems to stimulate deep thinking about learning among teachers, and that is worth it whether or not TA is a faithful representation of learning. TA also distributes power in education research, as opposed to RCTs. The participants are not faceless individuals, data sources. Their thinking is personal collaboration with researchers, in an atmosphere of willing consent and commitment. It really I social justice in action. For other thoughts on these issues see Hammersley's paper to the British Education Research Association in 2001, 'Some Questions about Evidence-based Practice in Education' (www 10.)

Think Aloud Protocol

The TA method came from usability studies in 1982 but like most methods has developed considerably since (see, for example van Someren et al, 1994 for a thorough account). Essentially, the participant is asked to talk out their thoughts. The most common method is the Live or Concurrent TA, where the talk is recorded as the task is completed, with the emphasis on description rather than interpretation. It is also possible to use Retrospective TA. We have used the Live form. It could be said to be a form of an open interview, since the researcher's role is simply to record (often audio) and to prompt for any more thoughts when the talk starts to flag. TA can often spring surprises, not least because control is much more given to the participant than in traditional interview techniques. One data analysis form is to transcribe the recording, with utterings, and then to subject the transcriptions to content analysis. This is very time consuming. In PALAVA, we have used a kind of Focus Group analysis, where the group members listen to the recordings iteratively, noting salient features and patterns, until saturation is reached, i.e. no new features or patterns are noticed. One advantage of this is that it also builds group cohesion and expertise. We claim that the process is less-directed than traditional interviewing but of course, prescribing the task is a form of researcher influence. It seems that researchers can give up some control of the research but not all! While the TA method is relatively easy to carry out, analysis is time consuming and can be challenging.

Advantages of Thinking Aloud

Teachers are frequently orientated to how their students explain practical procedures, concepts, calculations and how to answer questions. The procedures of TA, that include simply listening, and prompts for more talk, are exactly those required for deep discussions. TA encourages teachers not to foreclose interesting discussions. The processes of setting a task for the thinking, and allowing for elaboration, mimics part of general class activity, though not so usually extended or focused on one or two individuals. In this sense, they have a degree of authenticity. For teachers who wish to carry out Action Research, using TA, the richness of the data provides valuable exploration of much that is of interest in the normal classroom. It is, of course, a qualitative method, but could sit alongside more quantitative methods as a form of triangulation to establish validity.

Disadvantages of Thinking Aloud

By its very nature, TA is very time consuming, and demanding on the teacher remaining largely in the background. It is also very time-consuming in analysis and interpretation, as has been mentioned. It is quite possible that TA disrupts some normal thinking, since speech is so much slower than thinking. For younger participants, and with complex diagrams, the lack of appropriate vocabulary can also be a problem.

Case Study 1: What do we see in scientific diagrams?

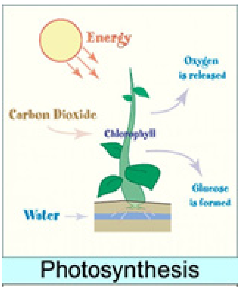

Figure 1. Scienttific diagram

Typical of the scientific diagrams we used was one similar to that above. We used TA, with analysis and interpretation by the PALAVA group. We noted the following:

1. Generally, most diagrams used a convention where the 'story' moved from left to right, with inputs coming in from the left, and outputs going out on the right. As in the diagram above, we noted that the sun's rays on photosynthesis diagrams were generally shown at the bottom right only, and generally moved

only a little way down. This was also seen in depictions of candles where the rays were shown, although in this case, the rays were seen on every side.

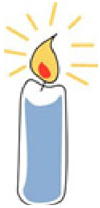

Figure 2.

2. Generally, we used complex diagrams, as in the ecology system shown below. (Note the rays of the sun, which still go out only a short distance, then stop, but they do go in every direction.)

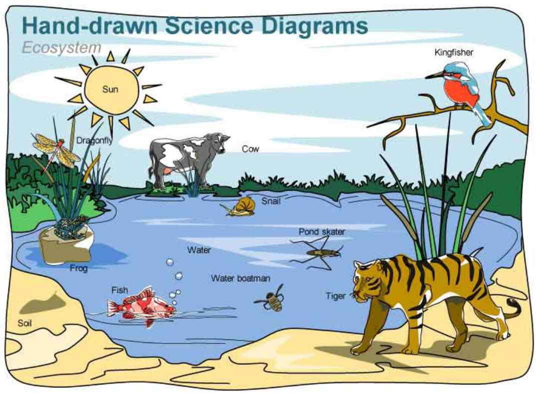

Figure 3. Scienttific diagram

3. With all diagrams except for those showing cycles, the participants noticed sections starting, generally from top left, and moving to bottom right. In between there was some revisiting but the general pattern was strong.

4. Participants were frequently able to notice only a relatively few features of the diagrams, despite being prompted to tell us all that they saw. For example, using a stylised diagram of a flower, observations ranged from 12 to 76, the latter given by a person well used to observing diagrams.

5. When we gave a diagram with some obvious parts missing, such as a chemical formula, some participants told us that they saw these parts! From an associated experiment where we videoed (David Marsh did this) the participants' eye movements (eye tracking) we found that the TA gave an average account of where the participant had looked over the past one or two seconds. The eyes

moved very quickly. We found that they included, from memory, items that they expected to be present. This is not surprising since we know the sharp focus of the eyes is limited to the images that are on the fovea part of the retina. The rest of the image then sets the (fuzzy) context for the part being looked at. For diagrams that are complex, there is obviously much to be taken in, or assumed.

6. TA use with diagram 'noticing' gives us some insight into the brain's operation, though we must always accept that this will be partial. However, we should not be too precious about this, since almost all forms of assessment provide only partial understanding of what is going on. The important thing is that we get some useful information.

Case Study 2: How does an individual construct a scientific diagram?

We asked participants (established teachers, and older students in schools) to construct a scientific diagram of equipment to separate two liquids by distillation.

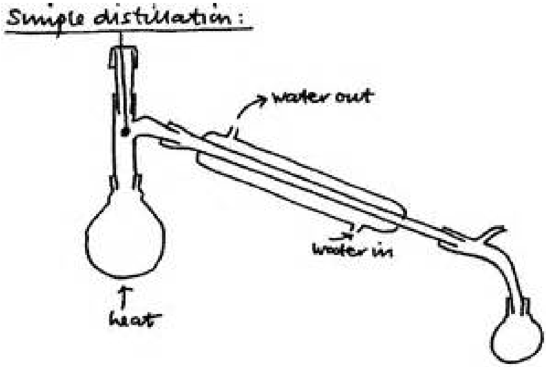

Figure 4. Scienttific diagram

We used direct observation by a group of teachers (members of the PALAVA teacher researcher group), and videoing over the shoulder, in conjunction with TA. The pattern we observed was that teachers of biology and physics, and school students, started with the condenser, then added the heating section, finally finishing up with the collecting flask. They explained that they drew the condenser first to make it 'look right on the page'. The chemistry teachers generally drew the heating section first, then the condenser, then the collecting flask last, explaining as they went along the 'story' of the process in chronological order. We understood this difference through an appreciation of the strength of knowledge of the different teachers and students. With the advent of pre-drawn diagrams for PowerPoint presentations, such niceties of construction as a pedagogical instrument are being lost.

Case Study 3: How do groups construct a scientific diagram?

Figure 5. Scienttific diagram

We gave a ruler to three members of the group of teachers. As in the diagram above, we asked them to balance the rule on the index fingers. While keeping the ruler horizontal, we asked them to move the fingers together until they touched. They did this three times to get a feel for the activity, without any discussion of the science behind the activity. Then someone held one of the index fingers while they repeated the activity. Finally, we asked them to move the fingers apart from the mid-point. They were surprised by much of the activity (even the physicists), especially when they could only move one finger in the last part. Some even tried to wiggle the fingers to get the ruler 'to do what it was supposed to do'! We then asked them to draw a diagram or diagrams, as a group, to explain to someone in the next room what to do (not to explain the physics). Working in a group prompted a kind of TA, although we noticed different levels of leadership and submission, rather than collaboration. In one case, a teacher separated from the other two and drew her own diagrams. We asked them to leave out text on the diagrams. We noted the following:

1. Working as a group was quite effective as a stimulant to TA, although it was limited by feelings of authority by different group members.

2. The participants were clear that they had considerable trouble in explaining the physics (they were all secondary science graduates).

3. They were unsure of what level of detail to include, often giving great detail on the fingers, or the graduations on the ruler. It seems that simplification is dependent on understanding what is going on.

4. We asked them to hold pencils in place of fingers, and to repeat the exercise. This time they drew the sharpened points of the pencils! Their discussions indicated that they still did not know how to explain the exercise.

5. Some groups used a story board method, with different diagrams to indicate the process, while some used arrows to indicate movement. This needs further exploration.

6. We came to the conclusion that group co-construction opens up different kinds of TA.

Case Study 4: Exploration of Teacher Subject Matter Knowledge

With my colleague, Jane Fieldsend, we set about to find out whether pre-service teachers of science, all graduates of one science discipline or another, could answer correctly, typical English examination questions aimed at higher achievers in external GCSE examinations taken normally at 16+ years of age. The tests were given at the start and end of a one-year teacher preparation course. There were slightly more biologists. The post-test was at the same level with comparable questions, according to examination board information. The mean results for the pre-and post-tests were:

Tabele 1.

Pre-test (N = 88) Data are mean %

Subject first degree	Biology questions	Chemistry questions	Physics questions
Biology	61.3	51.3	38.8
Chemistry	58.3	75.6	53.6
Physics	56.6	61.2	71.9
All students	59.4	58.8	47.8

Tabele 2.

Post-test (N =74) Data are mean %

Subject first degree	Biology questions	Chemistry questions	Physics questions
Biology	75.3	74.0	57.8
Chemistry	83.7	93.1	88.0
Physics	77.2	90.0	95.2
All students	77.4	80.8	71.1

This rather stark data did puzzle us for some time. We had these concerns:

1. Given that the pre-service teachers were all science graduates across the disciplines, we wondered why they could not score more highly on questions aimed at 16+ year old students.

2. We wondered why biology graduates only scored three quarters in biology questions at the course end.

3. We wondered why biology graduates did so poorly in physics, despite having studied this top age 16+ previously.

We presented a sample of 12 student teachers, near the end of their course, with one physics, one chemistry, and one biology question, in a TA context. The recordings were discussed by three teacher educators. We were surprised by tow discoveries:

1. The students had used procedures they had memorized, and made no

recourse to conceptual knowledge. We were testing recall of procedures, rather than problem-solving to answer a question.

2. When the student could not remember the procedure, or part of a procedure, they gave up completely. Only one student used a logical (not conceptual) approach.

The TA approach uncovered for us how the students answered these questions, whereas before we had only the bare evidence of the final outcome, the writing on the page. We decided we would be interested to know how the students taught examination technique in their practice schools, but did not have opportunity to carry out this research at that time.

What have we learned from Think Aloud research methods?

1. TA method is appropriate for practising school teachers (and probably for Higher Education and pre-service teachers) to carry out qualitative research, including Action Research.

2. Data collection is relatively easy (as long as there is not too much prompting) but analysis can be both time-consuming and challenging. Great care should be taken to check validity with one or more colleagues.

3. TA is readily accessible to see the effects of an Action Research cycle, using the data from TA to modify teaching.

4. TA research can result in publishable material.

5. TA research can give some insight into brain action, which is clearly central to learning.

6. TA research places more control in the hands (or head) of the participants. This can make TA research more authentic.

7. TA research in science education is not yet prolific, compared with its use in reading, for example.

8. TA research can sometimes surprise us, as with the examples given above.

TA has caused us to think about social justice in education research.

Tabele 3.

Method	RCTs		Think Aloud
Correlation or cause and effect	Correlation	↔	Cause and effect
Funding required	Expensive	↔	Cheap
HE v school-based	HE or research organisation	↔	Every level, including school
Validity and reliability	Reliable but validity depends on the survey instrument used. Validity suspect if survey instrument only constructed by researcher	↔	
Role of participant v researcher	Privileged towards the researcher	↔	Authentically collaborative between researcher and participant.

Implications for teaching and learning in science

TA is often used intuitively by teachers to explore a learner's understanding of a problem. Here we show how this can be developed and converted into a valid and rigorous research activity.

Further Research

TA can easily provoke ideas for further research, as I have indicated above. TA stands as a method that gives some control to the participants, which needs further exploration.

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Pedagogy or andragogy -

Or how to teach adolescents and young adults

Introduction

Education is an essential part in life of adolescents and young adults. In order to prepare adequate educational course for those people teacher must know and consider determinants that dictate the specificity of adolescent's educational process as well as differentiate it from education of children. A teacher, who's responsible for education of this particular age group, should not only know the principles used in their education but also be able to put them into practice. Adopting correct didactic solutions, which take student's needs into account, allow us to enable efficient and optimum organization of educational process as well as cause the increase in effectiveness of the whole process.

If we would like to assess the question raised in the topic of this chapter we must delve into psychological studies and contemplate differences in intellectual development between adolescents and young adults. Furthermore, we should look into disparity between pedagogy and andragogy.

Piaget's theory

Teachers responsible for natural science education in high school and university education come into contact with students that are already past 12 years old mark. Those students, according to Piaget's Theory, are on the formal operational stage of cognitive development. At this step of intellectual growth students are capable of understanding concepts by means of formulation of hypotheses that can only be verified by theoretical reasoning. The result of that is scientific thinking which manifests itself through solution of complex tasks and hypothetical problems as well as maturation of cognitive structures. What's more, this period of development is characterized by development of idealistic emotions and formation of personality. Once developed, formal operations last for individual's entire life, allowing him to think logically not only when it comes to specific "objects" but apply it to abstract thought and hypothetical events as well. The basic principles of formal operational thought are: hypothetico-deductive reasoning, scientifically-inductive reasoning, sentence or combinative operations, abstraction that reflects patterns in formal operation.

Hypothetico-deductive reasoning (transitoriness of characteristics, "What if") allows us to carry over attributes of known compound to the entire subfamily. Similarly, "What if" enables planning of experiences. Scientifically-inductive reasoning (which can be described as going from details to overall picture) allows us to create laws and dependencies based on the examples that we encountered. Sentence Operation, reflective abstract thinking can be used as a tool for using theoretical (or abstract) knowledge without referring to tangible object. An example of usage of formal operational patterns (such as probability, proportionality) can be seen in stoichiometric model of chemical conversion and in solving of algebra equations. The way of thinking of students older than 12 years old is complete. What those students possess is an comprehensive system for logical thinking, which can be applied to diverse types of dilemmas, including scientific and logical problems (Vasta Haith & Miller, 1995). Furthermore, students way of thinking acquires new traits such as cohesiveness, deductivness and regularity. They feel the need for consistency in their reasoning. Syncretic schemes what event are no longer adequate for them. What they apply instead is the analysis of the elements of knowledge (Piaget 1991). The role of observation is lower than at previous stages. Students are able to think about objects that there are unable to observe. Abstract thinking is typical for this stage of development. It is based on concepts i.e.: forms of representation that relate to general properties of objects, phenomena and situations or attributes and relations that are imperceptible by direct perception (Jurkowski, 1986). Abstract thinking is often the result of indirect cognizance. It allows us to grasp ideas like essence, phenomena and how they relate to each other. The foundation of abstract thinking is speech (Rubinsztejn, 1962). At this stage of development students are able to create classical definitions. New concepts are also picked up by means of definitions. At this level students intellectual development is at its peak. It's displayed through student's ability to comprehend content and abstract concepts. He is also capable of constructing complete designs and perceive relations between them (Nodzyńska, 2010).

Keeping this in mind it seems apparent that students who are older than 12 should be taught in manner similar to students of universities. All that remains is to ask following question: Which approach to education of adolescents and young adults is appropriate: the pedagogy or andragogy?

Theory Knowles's

Malcolm Knowles was one of the pioneers of research on the subject of adults education. Thanks to his effort knowledge about differences between education of children and education of adults became much more common (Urbańczyk, 1973). Pedagogy can be described as education and upbringing of children, whereas Andragogy is the name for education of adults. There is a huge difference between process of teaching children and education of adults. The most important disparities are shown in the table.

Table 1. Differences between pedagogy and andragogy

Pedagogic	Andragogic
Submission to teachers will	Self-sufficiency of learner
Experience is built as a result of process of learning.	Ability to relate new found knowledge to previous experiences
Reason for learning: CURIOSITY Children learn anything that they find interesting and novel	Reason for learning: The NEED Adults learn things that they deem useful in their lives
Motivation: EXTERNAL Children learn to be rewarded and get approval of people that are dear to them	Motivation: INTERNAL Adults learn to better handle the challenges at work and in their privates lives.

Knowles proposed a new method of teaching - andragogy model (so called "processual model"). It is significantly different when we compare it to the pedagogy model. It stems from the fact that pedagogy model only deals with transfer of knowledge and abilities while processual model focuses on procedures and resources which will aid student in acquisition of knowledge and skills.

According to Knowles, in pedagogical model it's the teacher that defines what kind of skills and what knowledge will be transferred to students in the process of teaching. After that, the teacher organizes contents into logical sequence and then he chooses adequate methods and techniques for teaching this subject. It's fair to say that in this model it is the teacher that dictates the content, goals and form of education.

It's different in processual model. Here, the teacher is responsible for:

- Preparation of student
- Creation of atmosphere that promotes learning
- Application of mechanisms that enables joint planning and diagnosing of educational needs
- Formulation of goals that satisfy those needs
- Designing formula for educational experiments
- Directing aforementioned experiments by using appropriate means and techniques
- Evaluation of educational results
- Re-diagnosis of educational needs.

In table n. 2 have been compared the principles of the two models:

Table 2. Elements of pedagogical and processual process:

Elements	Pedagogical Approach	Andragogy Approach
1. Student's preparation	minimal	providing the necessary information, preparation to participate, assistance in the formulation of realistic expectations initiate a reflection on the content of education
2. The atmosphere	formal, set towards rivalry, oriented on teacher	trust, mutual respect, informal, friendly atmosphere, cooperation, support, care
3. Planning	By teacher	joint planning by student and teacher
4. Diagnosis of needs	By teacher	joint diagnosis
5. Designation of goals	By teacher	bilateral negotiations
6. Creation of learning plan	Subject/field logic creation process is focused on content	sequential, based on students readiness, focused on problem
7. Methods and techniques	focused on knowledge relay	focused on the search
8. Evaluation	By teacher	joint reevaluation of needs, joint assessment of the program

Sours: Knowles, Holton & Swanson (2009) p. 108

Taking this into consideration it is clear that there's distinct disparity when it comes to education of children and education of adults. However, the question of when it is more adequate to apply andragogy over pedagogy is still left open to debate.

It is well known that as students get older their desire (and their ability) to self-govern grows steadily. Same can be said about their need for application of own experiences during learning process, identification of one's readiness to learn and organization of learning process around their everyday problems. Those elements develop particularly rapidly during the adolescence (Bower & Hollister, 1997; Bruner, 1961; Cross, 1981; Erikson, 1964; Getzels & Jackson, 1962; Iscoe & Stevenson, 1960; White, 1959). This level of natural maturation can be seen on the figure 1. presented below. It is presented as a gradual decrease in dependency of adolescents on others (continuous line). That is why in the first years of children's life usage of pedagogy's model is correct. But as the child gets older and matures the usage of anagogical model becomes more and more adequate. However, in our culture there is assumption (upheld by parents, schools and educational institutions) that this process is significantly slower than it really is (showed on the figure by usage of dotted line). The outcome of that is education of adolescents and young adults in way similar to educating children. This results in divergence between the need of self-governing and actual possibility of achieving it. Such restriction may cause unnecessary stress, anger and even teen rebellion (Swanson, Elwood & Knowles 2009).

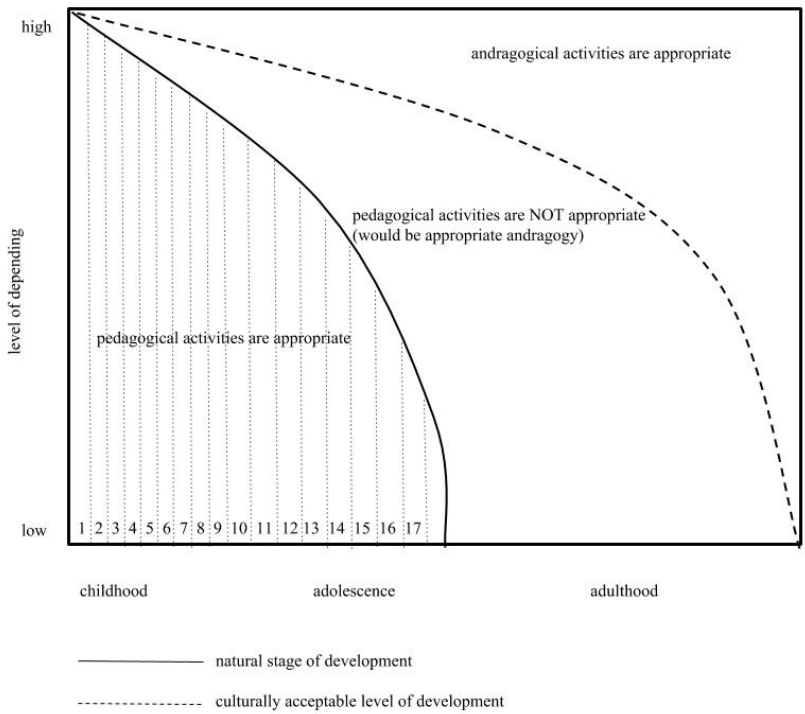

Figure 1. Level of development of self-reliance. source (Swanson, Elwood & Knowles 2009)

If we take into account the conclusions that we deduct from this figure it seems proper to use at least a mixed strategy (of pedagogy and andragogy) when it comes to teaching adolescents and to use exclusively andragogy when we're teaching young adults (students from universities and colleges). As it has been proven in this text, andragogy and pedagogy differ substantially and it is important to remember about that difference.

Psychological theories and andragogy

If we teach students according to the principles of andragogy we must remember that self-reliant student wishes to affect what content he's learning and he wants to decide on his own what he will learn and what he will skip. Teacher's role in this model is to support student while his educational needs manifest themselves. Student should also participate in the process of creating educational program and in selection of adequate techniques and methods. If such opportunity is not presented to students, they may refuse to participate in educational program presented by the teacher. Another discrepancy that is connected with the age of students is difference between children and adolescents minds. With younger children we can assume that their minds are *tabula rasa* - an empty board that is filled with knowledge by the teacher. On the other hand, older students (adolescents and older) mind is already filled with knowledge - in this case the teacher's job is to find "empty" space on this board to "squeeze in" new experiences - it is simply impossible to erase information that was already on the board prior to this particular process of teaching (Fig. 2.).

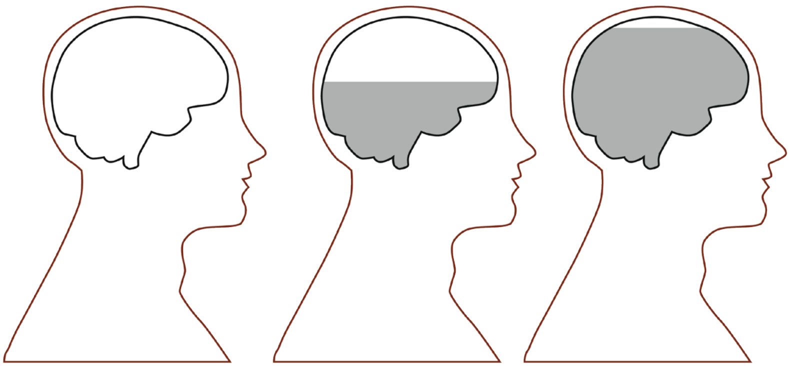

Figure 2.

It is because humans are "attached" to the knowledge that they already posses and as a result of that, the mind will "defend" itself against new ideas and theories. This process is explained by the theory of Cognitive dissonance. According to this theory following ideas that clash with our own beliefs makes us feel threatened by them. That is why our mind blocks ideas that could cause dissonance already on the perception stage while memory serves as another filter that sieves out unwanted ideas . As a result of that, students have a hard time acquiring knowledge that is in direct opposition to theirs internal views and convictions. Furthermore, upon memorizing they're more prone to forget those statements / ideas that conflict with their own. It is exceedingly difficult to reform wrong attitude that was shaped in course of education (Maruszewski, 1970).

Conducted psychological research on the subject of techniques applied in the process of learning suggests that previously acquired knowledge/techniques/ideas can affect process of gaining new information (Buchodolska & Włodarski, 1977; Włodarski, 1971). This influence can be positive if our previous experiences improve the memorization of new material – in this case its called "positive transfer". However, there is possibility of negative influence. It occurs when acquired information "inhibits" comprehension of new material. In this case it's called "negative transfer". This overlap of old experiences with new may display itself in direct way (so called specific transfer). It happens when transfer applies only to single activity .

Non-specific transfer refers to methods and techniques of learning. In this case the influence of an earlier education is much more profound if the exercise requires comprehension of the task rather than simple mechanical drill .

In psychology essays on the topics of impact of originally mastered terms/notions on comprehension of subsequent data we can find additional terms: proactive inhibition and transposition .

The term proactive inhibition is used when we're dealing with stimulus that causes two separate reactions. This generates negative transfer – that relates linearly to the disparity of reactions (the more distant are relations – the bigger negative transfer).

Instead of being response to particular stimulus, transposition can be described as reaction to relations and connections between stimuli. Josts Laws are another scientific source that brings attention to the topic of correlation between previously and currently acquired knowledge. First law states that as the times flows the strength of older associations declines more slowly than of newer. In other words – as people get older they remember only first impressions/associations connected with particular idea. Second law of Jost states that if two associations are of similar strength, but one of them is older (as in it was learned earlier in individual's life) then in case of repetition of those associations the older one will be favoured. This law also emphasises importance of first impressions connected with idea.

If we take all aforementioned arguments into consideration it is clear that we must recognize importance of past experiences if we intend to teach them something new. It is impossible to simply "erase" old information in the mind of the student and then replace it with something new. What teacher must do is find a way of adapting new material so that it may fit with the already present "picture". That is why it is crucial to teach adults by referring to what they already know. What's more, we should aim to recognize which pieces of information that are taught are similar/identical to what they already know and understand. It is worth trying to build positive conviction about the knowledge that they already possess and then build upon that positive image by linking with it new topics. That is why education of adolescents and young adults should be pervaded by techniques that stimulate participants and take advantage of his previous experiences e.g.: experiments, discussion or case study.

At this age bracket education should encourage exchange of experiences between students. Thus students are able to learn from each other and benefit from experiences of a whole group. (examples: flipped classroom, learning by teaching, experts discussion, aquarium discussion). For this to be possible we must create atmosphere that is beneficial to the exchange of experiences and based on mutual respect/understanding. Sense of security is also crucial to the success of method. It is teacher's responsibility to create such environment. One of the main reasons why students go to universities is their wish to implement acquired skills to everyday dilemmas that they will be faced with in their professional career. That is why teachers should demonstrate practical applications of what is taught in the classroom/lecture hall. This will assure students that what they are learning is useful to them.

Keep in mind that university/college students are extremely diverse group when it comes to their pace of learning– much more than teenagers in high school. This diversity is why many freshmen feel lost during their first semester. Therefore, academic teachers should be familiar with changes that occur during adolescence and he must be aware that it is simply not feasible to employ same strategies that are used in pedagogy while educating adolescents/young adults.

Theories of motivation

When it comes to education of adolescents and young adults we must pay special attention to students motivation and just how interested they are in a topic. When it comes to new things and ideas, adults are only capable of short-lived enthusiasm. That is why provoking curiosity works only temporarily. In the long run we must prove to them that this particular course can be useful for them in their private or professional life. Once convinced adults are prepared to learn – even if the subject is difficult and uninteresting. That is because while children are driven by external motivation, adults are motivated by internal impulses. Children learn to gain approval of those who are important to them (as well as rewards). If they refuse to learn it usually means that:

- their effort was not recognised (or they are not receiving reward for their effort)
- the awards that they received have no value to them
- teachers and parents are not considered "important" by children.

By contrast, external motivation works only on adults that are not self-reliant. Those who are self-reliant and resourceful don’t pay much attention to praises given by his teacher/coach or others. For this reason teachers must recognize the level of self-reliance of individual adolescent students. If particular student is still a bit immature it is teachers duty to encourage them by using both internal and external motivation (those students highly value opinions of others and desire to be praised). Contrarily, fully mature and self-reliant students require only internal motivation (such as explaining to them how what they learned can benefit them in their private or professional lives).

According to Knowles, main drive behind process of learning for young adults is internal motivation. This means that teachers should look for ways to inspire in reassure in students the need for self-improvement and help them in finding their own goals of education. It is also his/her job to illustrate to them how much they might gain from the whole ordeal.

Another factor that greatly contributes to stimulating internal motivation is to involve students in designing of courses program and to allow them to participate in defining its goals and methods of teaching.

Teaching practice

Based on those arguments we can see that in education of young adults and adolescents we should employ principles of andragogy. It is important that we consider implications of that – especially from teachers point of view.

First of all, the emphasis of the whole teaching process should be on EVOLUTION not REVOLUTION. This means that he/she should focus on expanding on already existing knowledge instead of trying to teach students something new . It stems from the fact that in adult students mind aside from common knowledge structures (which creates the core of minds of younger students) a structure of scientific knowledge exists. This knowledge comes from different sources such as experiences, social communication, books and from previous stages of education. If the process of learning promotes students activity it is much easier for participants to integrate their first-hand experiences with scientific knowledge (on condition that it is delivered in manageable “chunks). What we mean by that is if teacher wants to introduce new information and skills she/he should blend them with things that are already familiar to her/his students. This approach requires that teacher pays more attention to students previous experiences connected with learning and education.

On the other hand, those experiences may inhibit progress of learning. One of the reasons could be fear of something new as it disrupts certain “inner stability”. This may result in students distrust when it comes to attempts to change status quo and initial refusal of any novel ideas. Another important aspect of education of adults is that learned material is not only related to our own experiences but to those of group members as well. That is why we should select people with similar personalities and experiences when we're assembling group. We could also allow students to pick groups on their own. It is also up to teacher to ensure integration of the group (it is especially important if the group members are selected randomly e.g.: students in their first year of university before they can get to know each other). The easiest way to do so is to emphasise similarities between group members. If executed correctly it enables student to exchange experiences. Similarities shouldn't apply only to students - teacher may also be similar in certain ways to group members. This is why it is critical to avoid creating barrier between teacher and his/her students. Instead, we should accentuate similarities that connect teacher and students. Teacher must show himself as someone who fit in with the group.

The factor that is of crucial importance to education of adults is creating and maintaining atmosphere that supports acceptance and open-mindedness. Usually adults want to talk about their experiences, obstacles and successes connected with education but they're discouraged to do so if the group (and teacher) respond with criticism. Furthermore, they won't talk about it if they feel ignored or isolated from the group. Proper atmosphere should be formed during team building exercises.

As mentioned before in this article, motivating self-reliant students can be quite difficult. One of the method involves practical exercises in order to enhance motivation. It means that during lessons teacher should create opportunities for immediate application of newly-acquired skills (One example of this would involve short lecture followed immediately by laboratory class / auditory class that allows them to apply information obtained on preceding lecture.). As a result students can notice that acquired theoretical knowledge (from lectures) can be useful in practical situations (laboratory class). Such actions boost students internal motivation. If lecture is not followed by practical classes students are unable to recognize significance of this new knowledge and how it can be applied to everyday situations (Frankly speaking: He doesn't know "how can it be relevant to him/her?"). As a result she/he may lose motivation to learn. When teaching adults it is important to use examples. Most of them should be realistic and refer to specific, everyday experiences. Moreover, teacher should convert them so they apply to members of particular group. Abstract stories, exercises and games, even though they boost creativity, are difficult to relate to. That's why practical exercises are more adequate here.

Another important step in education of adults (which also boosts their motivations to learn) is to allow students to decide what they will learn and how will they learn it. Adults are much more eager to learn things that they deem important and useful. That's why we cannot force them to learn. While designing educational curriculum for adults we should allow students control following aspects:

• Choice of learning contents

• Methods of teaching/learning (by allowing them to choose teacher and model of studying: distance/blended/traditional learning).

When it comes to matching form of learning to students needs, it may be useful to use questionnaires and polls filled by students before and after each course.

What is truly critical in education of adults is that teacher should create situations in which students learn, experience and make decisions on their own, instead of relaying information to them. Adults have also different mindset than children when it comes to whole process of learning. Adolescents and young adults focus mainly on the results of the entire procedure. If goals are not achieved at a predetermined time the whole operation is considered a failure. This goal-oriented mindset deprives those students of pleasure that could be drawn from just participating in the whole ordeal.

The final difference between education of children and that of adolescents and young adults has to do with the position of control and evaluation in a process of learning. Adults and especially adolescents have distinct sense of individuality and dignity. That is why they are very (maybe even excessively) sensitive when it comes to evaluation and control. It is especially true if the form of evaluation/control does not separate evaluated person from his/her behaviour and creations. Adolescents will only accept this form of evaluation (or control) that, apart from informing them “what is the state of things”, gives them feedback on how it can be improved and in what steps should be taken to correct and enhance it. It should also be clearly formative in nature.

Summary

After taking into consideration psychology theories, discrepancies in intellectual development, differences in drives and motivations and analysis of previously acquired knowledge at both stages of development it seems evident that education of adolescents and young adults should be carried out accordingly to principals of andragogy. This requires radical revision of current methods of teaching which are applied in high schools and universities, as current approach is highly pedagogical and it reduces students to childishness (Gombrowicz, 1937).

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