Science Teaching in the XXI Century

editors

Paweł Cieśla & Anna Michniewska

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Introduction

This monograph is an overview of current problems and educational activities undertaken in the field of natural sciences, as well as the results of research on the effectiveness of various forms of this education. Particular emphasis is placed on the integration of information and communication technologies, including mobile technologies, in the teaching and learning of natural sciences.

The monograph consists of 15 chapters prepared jointly by 28 authors from the Czech Republic, Slovakia, Poland, Russia and Armenia.

I hope that the publication will be an inspiration for scientists to further research in didactics of natural sciences, and will be a source of ideas for teachers in their educational mission.

Paweł Cieśla

Focusing and Creating of IBSE Chemical Activities

Introduction

The significant change of the content of scientific subjects, including chemistry that happened in Czech Republic in the 1980's was the only one, for many years to come, to significantly change the contents of chemistry teaching at our secondary schools. The basic of general chemistry – composition of atom, chemical bond, chemical action and its laws – became the starting points for further chemistry education at these schools. Gradually, it turned out that this mostly deductive way of teaching wasn't entirely useful for all students. According to Held (2014), while this conception of subject matter does correspond to the trends in chemical science and in college teaching of chemistry, it's not adequate (based on the options of mental development) for beginning chemistry students with low degree of the development of formal thinking. This form of teaching resulted in students not grasping the basic chemical terms, not relating them to the chemical phenomena, and memorizing chemical facts and ways to solve chemical problems without really understanding them.

This was observed by both teachers and employers of the school graduates, and it was also seen in the international research PISA (Programme for International Student Assessment) which determines the results of students' education at the end of the mandatory schooling from the point of view of the job market's demands. The goal of this research, organized since 2000 in three-year intervals, is to determine the level of skills and abilities of 15-year old students that are necessary for their further development, profession and successful integration into society. During the testing, the importance is not put on the reproduction of the subject matter, but on the ability to apply the knowledge and skills in real life. The results have shown that our students have acquired many facts but they have a problem to independently think about scientific phenomena and relations, to research them, to create hypotheses, to find ways to solve problems, to interpret the data they found, to use the evidence they found and to form conclusions (Čtrnáctová et al., 2013).

Many other European (and other) countries also started pointing out the problems with the science education and related decrease of interest in these scientific disciplines; all in all, there was a feeling that the school education needs to be changed, since the traditional school teaching doesn't sufficiently prepare the students for life in the current society. The students throughout Europe consider the science subjects, especially physics and chemistry, difficult, and they don't think the subject matter of these subjects is necessary for their everyday lives, but if we look at it from the point of view of the societal needs, it's necessary to make as many students professionally dedicate themselves to these scientific and technical disciplines (Řezníčková et al., 2013; Čtrnáctová et al., 2014). In this situation, European Union (EU) enters the situation, granting substantial resources as a part of the European projects to support the change and development in science education.

The creation of the Science Education Now (Rocard et al., 2007), report which officially named the problems in science education and suggested ways to resolve them is considered an important milestone. This report says that one of the solutions of the current situation could be the application of the IBSE approach (Inquiry Based Science Education). IBSE is a method of teaching based on the students' own inquiries that uses many activising methods. It is a process of stating a problem, searching for information, setting and verifying hypotheses, planning research, conducting own experimentation, forming models, forming conclusions, discussing, and so on. It can be said that this approach has everything necessary to resolve the weak points of current teaching, as they were summarized in the conclusions of the international PISA research.

The implemented and approved educational projects of EU's 7th Frame Programme clearly shows the importance ascribed to the application of this approach in science education: the project containing IBSE are in a great majority. One of the first projects, aiming mainly to create materials for IBSE teaching, was the ESTABLISH (European Science and Technology in Action Building Links with Industry, Schools and Home) project (www.establish-fp7.eu), implemented in 2010-2014. The project solvers were 14 institutions from 11 European country; the main coordinator was Dublin City University (DCU). On the other hand, one of the last projects implemented as a part of EU's 7th Frame Programme was the TEMI (Teaching Enquiry with Mysteries Incorporated) project (www.teachingmysteries.eu) which ran in 2013-2016. This project involved 13 institutions from 11 European countries; the main coordinator was Queen Mary University of London (QMUL). The Faculty of Science at Charles University, Prague was a co-solver of both of these projects.

In this text, we have first focused on brief characterization of IBSE, on mentioning the rules of inquiry-based activities in chemistry education at secondary schools and on examples of such activities, created as a part of the abovementioned projects.

The characterization of inquiry based chemistry teaching

Inquiry based education means a significant change of approach toward chemistry teaching. Its main goal is to really understand the chemistry subject matter and to retain the acquired understanding for a long time, not just to remember a set of facts for a while, until the student uses them during an examination, and subsequently forgets them. This way of teaching develops the students' ability to solve problems, their critical thinking and their creativity. The teacher is not giving the students the subject matter as a finished product but leads them through asking questions and gradual solving of problems to acquire new knowledge and skills. The teaching follows a style analogical to real research: suggesting the research question, discussing possible solutions and formulating hypotheses, verification or falsification of hypotheses (usually through experiments), getting and processing results, discussing and forming conclusions (Franklin, 2000; Liewellyn, 2002).

There is a research cycle that maps how the scientists perform their research, and teaching based on inquiry can be also visualized using various analogical models which can be all considered variations of so-called "learning cycle". The most often used model is the model of five-stage learning cycle "5E".

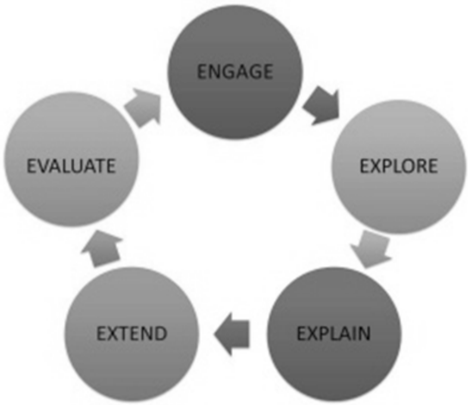


Figure 1. Learning cycle 5E.

The first stage in this cycle, the *engage stage*, focuses on arousing the students' interest about the given theme; the teacher motivates the students with unexpected happenings in an experiment, a video, a story in the media, an introduction of "chemical" mystery, etc., and the students find that they are unable to explain the situation with their current state of knowledge. In the second stage, the *explore stage*, the inquiry starts; the students or the teacher ask questions, suggest and develop hypotheses pertaining to the given theme, start collecting data and information, suggest and gradually implement observations and experiments. In the next stage, the *explain stage*, the data and evidence found in the previous step are processed, there is discussion and the scientific notions connected with the research are explained. In the *extend stage*, the results and acquired knowledge are extended to new situations, and in the final, fifth stage, the *evaluate stage*, supplemental and more complex questions appear in order to help the students evaluate and analyze their work.

Students and their teachers go through this five-stage cycle implemented as a part of inquiry based education together. Next, we can specify several levels of inquiry-based education based on the degree of students' own activity and the activity of the teacher, from a level lowest student activity to a level where the students more or less do everything by themselves. It is possible to describe 4-6 levels of inquiry (Kireš et al., 2015); we show a five-level system here (ESTABLISH team, 2010) (see Table 1).

Table 1. Levels of inquiry based science education.

Learning cycle stages / IBSE level	Engage	Explore	Explain	Extend	Evaluate
Interactive demonstration	teacher	teacher	students	teacher	teacher
Guided discovery	teacher	students	students	teacher	teacher
Guided inquiry	teacher	students	students	students	teacher
Bounded inquiry	teacher	students	students	students	students
Open inquiry	students	students	students	students	students

This table clearly shows that the students' self-reliance gradually increases as the level grows; this is so-called "Gradual Release of Responsibility"(GRR) (TEMI team, 2015).

In *interactive demonstration*, the teacher sets a research question, shows an experiment, plays a video, introduces a story or a mystery, etc., while asking the students questions pertaining to what will happen (prediction) or how something could have happened (explanation), guiding the students in order to reach the correct conclusion. In *guided discovery*, it is once again the teacher who sets the research question and designs an experiment, which the students will perform based on the already prepared instructions. It is, then, a standard laboratory exercise focused on verifying the information that were already mentioned during the lessons. The main feature of *guided inquiry* is that the students perform the experiments they have suggested on their own, searching the answer to the research question set by the teacher. Their explanations and conclusions are solely based on the results of their own work. *Bounded inquiry* expects that the students will design and perform the experiment on their own, with only a minimal teacher influence. The teacher sets the research question, but the students are responsible for designing and performing the experiment, as well as processing, extending and evaluating the data they obtain. *Open inquiry* presumes that the students themselves should suggest their research question, design and perform a suitable experiment, and subsequently process, explain, extend, and evaluate, if necessary, the data they obtain. This way, the students are able to actively obtain necessary knowledge, skills and abilities.

While the lower levels of IBSE are fairly common at our schools, for example during a presentation of a demonstrative experiment or during a laboratory exercise, the higher inquiry levels which present true IBSE are, so far, fairly rare. One of the main reasons for this is that there are not enough suitable problems for inquiry-based chemistry education.

One of the goals of the TEMI and ESTABLISH projects was to create suitable teaching and methodical materials for inquiry based science education (which were practically nonexistent in Czech Republic when the ESTABLISH project started in 2010) and verify them in practice. By participating in solving these projects, we gained an opportunity to participate in the creation and verification of these materials, and thus help inquiry-based education become a real part of chemistry teaching even in our country.

Selected inquiry based activities for chemistry teaching

In the ESTABLISH project, themes selected from physics, chemistry, biology and nature science were eventually processed via IBSE approach. Each of these themes was processed as one complex unit, divided into subunits based on the theme's scope; the subunits were then divided into activities corresponding to time lengths of 1-2 lessons. Altogether, there was 18 complex materials created; their summary can be seen in the Table 2. As a part of processing these themes, educational and methodical materials were created for over 250 activities.

Table 2. Educational and methodical materials of the ESTABLISH project.

Theme	**Subject**
Designing a low energy home	Physics
Direct current electricity	Physics
Light	Physics
Sound	Physics
Cosmetics	Chemistry
Photochemistry	Chemistry
Chemical care	Chemistry
Photosynthesis	Chemistry
Polymers around us	Chemistry
Exploring holes	Chemistry
Chitosan – fatmagnet?	Chemistry
Disability	Biology
Blood donation	Biology
Ecobiology	Biology
Water in the life of man	Biology
Forensic science	Nature Science
Medical imaging	Nature Science
Renewable energy	Nature Science

Complex unit starts with an introduction that contains information for teachers; these include the general characteristics of the whole theme and way to process it, and contain these parts:

- *IBSE nature* – the basic description of the theme and the way the IBSE approach has been applied to it;
- *scientific content knowledge* – basic information about the theme based on the specific science or integrated scientific knowledge;
- *industrial content knowledge* – the relation between the theme and practice/ industry;
- *pedagogical content knowledge* – the educational goals of the theme and its relation to curricular documents with options how to integrate it into the lessons;
- *course of teaching* – the description of the structure of the theme and its division, suggested ordering of the problems and listing of the inquiry levels related to the learning cycle in the individual tasks;
- *evaluation* – a suggestion how to evaluate the problems in the school practice.

The methodical materials then list, for each activity, its specific goals, curriculum content, suggestion about how to work, the review of the tools, devices, chemicals, natural materials, etc., to use, and the authors' solution of the activities with additional information. Then, there are educational materials for the students processed into the form of worksheets. Each activity got a worksheet with problems that guide the students through their own work on the given inquiry. The authors of this contribution, along with their coworkers at the Faculty of Science at Charles University in Prague and the Faculty of Science at UPJŠ in Košice processed the theme *Polymers around us*, on which we can show the main characteristics of the created groups of inquiry based activities (Ganajová et al., 2012; Čížková et al., 2013).

The introduction to the teacher-determined theme contains, according to the proposed structure, the basic description of the whole theme and the way of using inquiry based education. At the beginning, the majority of the proposed activities belong to guided inquiry and bounded inquiry, in later phases there is also open inquiry as a part of following the properties of polymers and suggestions how to use them in practice. Next part is the explanation of classification, structure, properties and behaviour of selected natural polymers, as well as synthetic polymers – plastics, the principles of their processing and ways of using them, advantages and disadvantages of plastics, as well as possible ways to eliminate plastic waste. The pedagogical part shows where this theme could be used as a part of current chemistry teaching at primary and secondary schools. The educational methods used in this unit are mainly guided discussion, problem teaching, group and cooperative teaching and project teaching. The students can be evaluated based on the results of their experimental work and their solutions of specific problems in the worksheets.

The theme was divided into three subunits, consisting of 28 inquiry based activities in total:

Plastics – this subunit contains the components *Types of plastics and their labels* and *Properties of plastics* (10 activities in total). The students will learn how to orient in the labeling of plastic products, and experimentally verify selected properties of commonly known and used plastics – PE, PP, PVC and PS – like density, flammability, solubility, heat and electric conductivity, solidity and reaction with acids, bases and salt solutions. The results of the observation are recorded in a table; the students reach conclusions which they subsequently try to explain, based on their knowledge.

Plastic waste – this subunit contains the components *Degradability of plastics in nature*, *Separating plastics*, *Effects of acid rain on plastic products* and *Recyclation of plastics* (5 activities in total). In these activities, the students think about the problem of plastic waste disposal, discuss it with their classmates, and suggest possible solutions. The students come to the realization that recyclation of plastics is an effective solution of their disposal.

Polymers around us – this subunit contains the components *Materials around us – polymers and plastics*, C*reating polymers and influencing their properties*, *Properties of polymers and their identification*, *Use of polymers*, and *Importance of polymers in the everyday life* (13 activities in total). In the introduction, the students are to write down 10 arbitrarily chosen items and guess what materials they are made from. After stating the characteristics of polymers and plastics, there will be a review of selected synthetic polymers, and a set of experiments with them where the students will create some polymers, research their properties, like appearance, density, hardness, resistance to chemicals, and behaviour while heated or in flame, and finally, based on these properties, they identify unknown polymers, research their use, and eventually summarize the importance of polymers in the everyday life.

Each of these activities is processed into the form of teacher's methodical material and students' educational material – a worksheet. As an example, let's have a look at the problems belonging to the activity *Properties of polymers – elasticity and cross-linking.*

PROPERTIES OF POLYMERS – ELASTICITY AND CROSS-LINKING

Goal and course of the activity

The students should use a simple experiment with a balloon to explain the properties of the polymer it's made of on the basis of its molecular structure (cross-linking, chain stretching, etc.)

Materials

balloon, wooden skewer, vaseline

Task for the students

Task 1. Is it possible to push a wooden skewer through an inflated balloon without popping it immediately? Inflate a balloon, smear vaseline on the skewer, and attempt to push it through the balloon with slow, rotating movements.

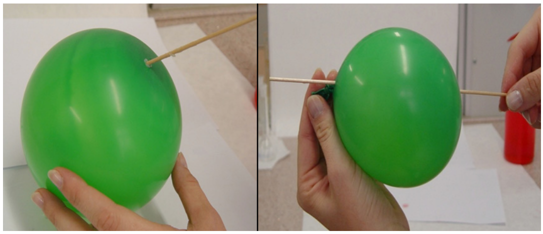
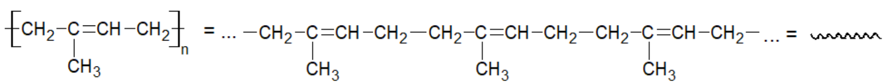


Figure 2. Pushing a wooden skewer through a balloon.

Task 2: The balloon is made out of cross-linked polymer called polyisoprene (poly-2-methylbuta-1,3-diene).



Try to explain the behaviour and properties of the polymer, based on your knowledge of its cross-linked structure. Cross-linking can be shown in a simplified way, as in Figure 3.

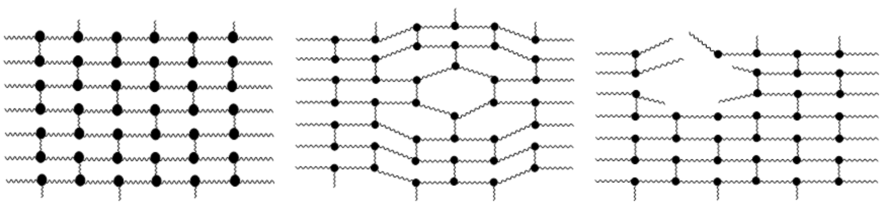


Figure 3. Cross-linked polymer; Stretching of cross-linked polymer; Tearing of cross-linked polymer.

Discuss and explain:

1) How is it possible that the balloon won't pop when you stick the skewer through

slowly and carefully, but it will pop when you use more sudden movements?

2) Why is the balloon more likely to pop when pushing the skewer in transversal direction instead of along its length, through the nodes?

When the students push skewers through balloons, they will find that not every experiment is successful, but in the end, they will manage to do it. What is the explanation? It can be shown in a simplified way, like on the Figure 3. The cross-linking of the polymer will hold its molecules connected and allow their stretching until a certain point where the force or stress on the transversal bonds is too big, the bonds get broken, and the polymer tears.

All teaching materials created as a part of the ESTABLISH project are available in English and Czech at the project website. The Czech version of the materials focused on chemistry and biology is also available in print (ESTABLISH team, 2015).

While creating inquiry based education activities in the TEMI project, four basic aspects were respected, as you can see in Figure 4 (TEMI team, 2015).

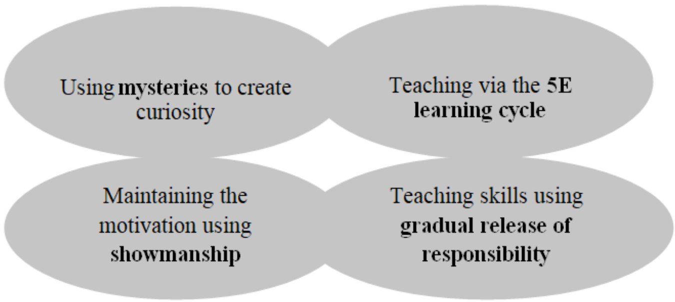


Figure 4. The basic aspects of the TEMI project.

The first aspect is the use of "mysteries" to engage and motivate the students. What is, in chemistry teaching, considered a "mystery"? It can be defined as a phenomenon or an event that creates a feeling of suspense and astonishment in the students, which triggers an emotionally charged feeling "I want to know" which promotes curiosity and leads to asking of questions that can be answered by activities during problem solving. Another one of the aspects is the use of the 5E learning cycle. Next, there is the gradual release of responsibility (GRR) where the teacher gives up the responsibility for teaching and passes it to the students. The goal of the inquiry based education should be that the students pass through levels from guided discovery through guided inquiry and bounded inquiry to open inquiry. Thanks to the different levels of inquiry, the students will be more and more able to conduct their own independent inquiries, and the teacher's help will start to be less instructive, and more advisory and flexible.

The last, but not least of the aspects is to ensure the students' interest throughout the implementation of the teaching of the given theme. Therefore, this aspect needs to resolve the question: If you manage to get the students' interest, how will you keep it throughout the inquiry? Our answer is "showmanship," by which we mean various presentation techniques that increase the drama of our inquiry. The research in education confirms that the students remember the subject matter better when it's presented in a dramatic way. Magicians, actors and other communicators have the instinctive grasp of the idea how to maintain curiosity by opening and satisfying "gaps in the knowledge". Their goal is to ensure that the audience will want to know something, and therefore they will examine and keep their attention until they find out. This is exactly the skill that teachers need. If they manage to use the scientific knowledge as answers to provocative questions, the lessons will be more interesting and meaningful. The most common examples of presentation techniques we use are storytelling, pantomime, "living pictures," dramatic illustration, or even "scientific" theatre (TEMI team, 2015).

As an example, let's have a look at the problems for the activity Mystery of Gibraltar.

MYSTERY OF GIBRALTAR

Guidance notes for teachers

<u>Engage: CAPTURE STUDENTS' ATTENTION</u>

Tell the story about how in ancient times sailors found out that there's a strong current in Gibraltar from the Atlantic to the Mediterranean. They also knew that the Mediterranean is surrounded by land. How can the water flow in and not out?

What factors make water flow (difference in height, temperature, pressure, salinity, etc.)? Do they apply to this case?

<u>Explore: COLLECT DATA FROM EXPERIMENTS</u>

The students can try to explain this mystery with their prior knowledge about salt water and pure water and come to the explanation of difference in salinity due to evaporation in the Mediterranean. The students can prove this hypothesis by demonstrating an experiment with two bodies of differently coloured water: one is pure water (the Atlantic) and the other is a salt solution (the Mediterranean). First, the students can try out pouring these liquids over each other with drinking straws. Second, they can make their own model of the strait of Gibraltar (see below) with a plastic box. Put duct tape over the holes, pour the two solutions into the two halves, and remove the tape: you will see two different layers and currents.

Explain: WHAT'S THE SCIENCE BEHIND THE MYSTERY?

Due to the different densities of the water, the water flows through the holes and forms two layers. There is a current flowing back from the Mediterranean to the Atlantic but it's near the bottom of the sea; thus, the ancient sailors had no way of knowing about it.

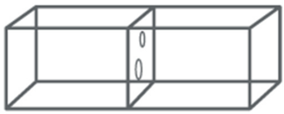


Figure 5. A simple model of sea currents.

Extend: WHAT OTHER RELATED AREAS CAN BE EXPLORED?

This is the way ocean currents work. There are also some other experiments with salt water (the floating egg, the testing of ripeness of fruits, etc.) that can be used to reinforce ideas about the density of different salinities of water.

The students can try to explain this mystery with their prior knowledge about salt water and pure water and come to the explanation of difference in salinity due to evaporation in the Mediterranean. The students can prove this hypothesis by demonstrating an experiment with two bodies of differently coloured water: one is pure water (the Atlantic) and the other is a salt solution (the Mediterranean). First, the students can try out pouring these liquids over each other with drinking straws. Second, they can make their own model of the strait of Gibraltar (see below) with a plastic box. Put duct tape over the holes, pour the two solutions into the two halves, and remove the tape: you will see two different layers and currents.

Evaluate: CHECK THE LEVEL OF STUDENT SCIENTIFIC UNDERSTANDING

Students are evaluated in a group discussion. The teacher asks questions to see if they have understood the concept correctly and what they learnt from the lesson.

Showmanship: TIPS ON HOW TO TEACH AND PRESENT THIS MYSTERY

The teacher can first tells the class a story about sailors trying to figure out how does the Strait of Gibraltar work – how come the water seemingly only flows in one direction? Where does it go? The story should increase curiosity about the subject in students. It is also possible to show a video of ocean currents etc.

GRR: TEACHING SKILLS USING GRADUAL RELEASE OF RESPONSIBILITY

Setting up the mystery: tell the class a story about sailors sailing through the strait of Gibraltar.

Demonstrated enquiry (level 0): the teacher shows the class the coloured water model of the strait with the horizontal layers. He or she asks about the explanation and the difference between these two layers apart from the colour. The teacher thinks aloud about the salinity of the sea and that maybe the two layers have different salinity levels. The students record their thinking onto their hypothesiser lifeline worksheet.

Structured enquiry (level 1): students use their hypothesiser lifeline sheet to record their own alternative ideas about why the Mediterranean does not rise infinitely and to where does the water disappears. They also record their tests and conclusions regarding these other explanations.

Solving the mystery: students are led towards the explanation by using ideas about salinity and different densities of differently concentrated solutions of salt and other substances.

STUDENT WORKSHEET

Engage: WHAT'S INTERESTING?

Task: The Mediterranean always seems to be thirsty: there is a strong current flowing into it from the Atlantic through the Gibraltar strait. However, the water has no way out of this sea, since it is surrounded by three continents… or does it?

Explore: WHAT'S HAPPENING?

Task 1: Can water only flow into the Mediterranean and not out? Or is there another way out we don't see?

Task 2: How salty is the water in the Mediterranean compared to the Atlantic? Is it important?

Explain: WHAT'S CAUSING IT?

Task 1: The density of water is affected by its salinity. What happens when two different types of water meet?

Task 2: Explain why we'd expect a second current in the Gibraltar strait. Why did the sailors only notice the one flowing into Mediterranean?

Extend: WHAT'S SIMILAR?

Task: The world's oceans have a complicated network of currents. Are they all based on salinity or is there another factor that affects the density of water?

Evaluate: WHAT'S MY UNDERSTANDING?

Task: Why exactly is the Mediterranean saltier than the Atlantic in the first place? What factors account for this?

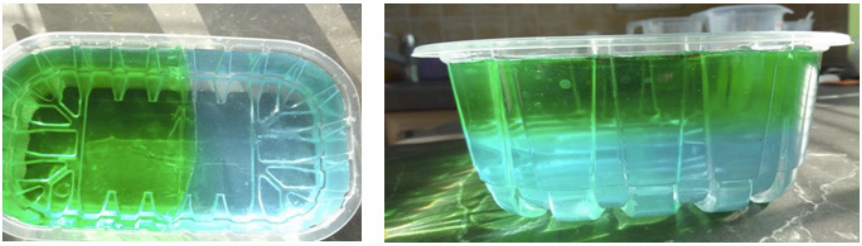


Figure 6. Initial and final situation of experiment.

All teaching materials created as a part of the TEMI project are available in English and Czech, both on the project website, and in print (TEMI team, 2016).

Conclusion

Both international and national research and surveys performed since the 1990's prove that the student knowledge of science is often formal and short-term without deeper understanding and the ability to apply it in practice. IBSE, as a new teaching method, seems to be suitable for improving the current state. Its use in science teaching depends on the valid curricular documents that must create a space for such teaching; there must be suitable materials for it; the students must be able to accept this way of teaching and the teachers must be able to teach in this way.

In 2010-2016, when we were a part of the projects ESTABLISH (European Science and Technology in Action Building Links with Industry, Schools and Home) and TEMI (Teaching Enquiry with Mysterious Incorporated) of the 7th FP, we have focused, among other things, on the creation of suitable materials for inquiry-based education.

First, we have established criteria for the materials creation, and then the individual materials were created to be suitable for science teaching at secondary schools. The materials we have created went through verification at schools and final corrections. Our work has resulted in five extensive publications presenting the materials corresponding to teaching of science at primary and secondary schools. This is why this text focuses on the introduction of these materials and their examples. The creation of suitable IBSE materials is the starting point for the introduction of IBSE into teaching. In order to get positive results during longterm application of this approach in teaching, the teachers have to be taught how to use this approach in practice.

This is why our further work focuses mostly on the verification of prepared materials and their use in the training courses for pre-service and in-service teachers, so both groups could get acquainted with this new way of teaching chemistry and use it in their teaching.

Acknowledgements

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Verification of IBSE Chemical Activities and Their Use in Teachers' Training

Introduction

Chemistry, as one of the sciences, has been an important subject at the secondary schools for a long time; currently, it belongs to the educational area "Humans and Nature," a part of the frame educational programme (RVP, 2005 & 2007). This means that all students at these levels go through 3 to 6 years of chemistry education. This might lead one to thinking that they will be well-acknowledged with the basics of the discipline and they will have no problem orienting themselves in chemistry in their everyday lives. The reality, however, is very different. The students, not just in the Czech Republic, but also in other European (and other) countries, consider scientific subjects, especially chemistry and physics, difficult, and they think that the subject matter of these subjects is useless in their everyday lives. However, it's necessary, from the point of view of the societal needs, to have as many students professionally dedicating themselves to science and technology disciplines as possible (Čtrnáctová & Zajíček, 2010). Many countries have started pointing out the problems with the way chemistry and other scientific subjects are taught, as well as the fact that the interest in these sciences is falling. There was an increasingly strong general feeling that there is a need to change the school education, since the traditional education is insufficient in preparing the students for life in the current society. In this situation, EU enters the area and grants, as a part of European projects, significant resources in order to support the change and development in science education.

The creation of the Science Education Now report (Rocard et al., 2007) which officially named the problems in science education and suggested ways to resolve them is considered an important milestone for the changes in science education in the EU. It seems that one of the solutions of the current situation could be the application of the IBSE approach (Inquiry Based Science Education) (Řezníčková et al., 2013; Čtrnáctová et al., 2014).

The implemented and approved educational projects of EU's 7th Frame Programme clearly shows the importance ascribed to the application of this approach in science education: the project containing IBSE are in a great majority. One of the first projects, aiming mainly to create materials for IBSE teaching, was the ESTABLISH (European Science and Technology in Action Building Links with Industry, Schools and Home) project (2010-2014); on the other hand, one of last projects implemented as a part of EU's 7th Frame Programme was the TEMI (Teaching Enquiry with Mysteries Incorporated) project (2013-2016) which was mainly focused on teachers' training. The Faculty of Science at Charles University, Prague was a co-solver of both of these projects.

As a part of this text, we focused on the ways of verifyinig inquiry-based activities in practice and their use in pre-service and in-service teachers' training.

Verification of activities of inquiry based chemistry education

The creation of educational materials for IBSE chemistry education in Czech Republic has started around 2010 and it's been expanding lately. Both educational institutions and nongovernment educational organizations offer whole groups of activities as IBSE education friendly. This is not always the case. The activities offered there often not only require disproportionally high investment of time and materials, but, more importantly, they do not follow the basic principles of inquiry based education. After the students are initially motivated, they get tasks which do not require them to do their own work, but only to find the correct answer in the textbook or on the internet. Incorporating these activities into lessons as "IBSE activities" is, of course, undesirable, and this is why each activity should be verified by an experienced pedagogue before entering the wide practice, and why the results of this verification should be used for optimalization of such activity.

This is how the themes processed by the ESTABLISH project (ESTABLISH team, 2015; Čížková et al., 2013) were verified. The goal was to find, whether the problems are understandable for the students, whether they aroused interest in them, and whether they are willing and able to solve them on their own, what are the true time requirements of the problems created, as well as other aspects. The verification of selected activities was also done at secondary schools in the Czech Republic and Slovakia. In the Czech Republic, we verified selected activities from the units Exploring holes, Chemical care and Polymers around us; 367 students in total participated in the verification (96 primary school students and 271 secondary school students). For Slovakia, the activities of two units, Exploring holes and Polymers around us, were selected for verification. 290 students in total participated in the verification (124 primary school students and 166 secondary school students).

The reason why we verified the activities was mainly to find out how they work in real lessons with real students, who these activities are primarily meant for, and to get some feedback about their quality, possibilities, effectivity, etc. The main source of information was the direct observation of students performing these activities, complemented by giving short questionnaires about them. The statements in the questionnaire were related to the meaningfulness and importance of the activity, as well as the interest it arouses, how much it increases (or decreases) interest of the students about the given problem, etc. Each question was evaluated using a seven-point scale form 1 (total disagreement) to 7 (total agreement).

The verification of selected activities in the unit Exploring Holes, focused mainly to methods of mixture separation, was done with the students of lower-secondary schools and upper-secondary schools (218 students in total). During the first verification, the students (97 in total) were to do a fairly high number of activities during a laboratory exercise: to solve a problem with criminal mystery component using the separation methods they knew, to fill in a worksheet about engine filters, and to perform an experiment with dialysis membranes. The students were able to complete the activities, but they probably didn't have enough time for discussion with their classmates, and so they didn't always reach specific conclusions. Another weak point of these activities was that the original materials didn't mention, for example, the size of pores in the dialysis membrane, the colorings that should be used for preparation of the solutions, or the results the teacher should expect. This meant that the students were unable to get the requisite feedback for their results. All of this could be projected into the evaluation of the activities. The subscale of meaningfulness and importance had the average value of 4.08; the subscale of presence of choice had a similar average value of 4.05. Better ratings could be found on the subscale of enjoyment with average value of 4.5, with statements like "I really enjoyed this activity" having median of 5; statements like "I found this activity boring," on the other hand, had average value of 2.68 with median of 2. The subsequent verification (with 121 students in total), the students were only doing the criminal mystery in the course of 2 lessons, using the separation methods they knew to solve it. The students were given a sufficient space to discuss their work when both solving the problem and making deductions about how the case could have happened. The students worked very diligently and engaged in a lively discussion about the way the victim could have been murdered. The results of the student questionnaires in the meaningfulness and importance subscale had the average value of 4.84, with the subscale of choice having the average value of 4.22. Statements focusing on enjoyment during solving the activity had the average value of 5.39, with medians of nearly all such statements at 6, while the statements calling the activity boring had the average value of 1.69.

The Chemical care unit, focusing on the properties of chemical substances, mainly connected with their bond interactions, was separated into several activities. We have selected the experiments related to household cleaning agents for the verification. The experiments aimed to research the acidity and basicity of the cleaning agents the students brought from their homes. First the acidity is examined (via simplified neutralization), then their reaction with metals and calcite, and finally their cleaning power. This material was verified with students of upper-secondary schools (161 students in total). The students generally approached the experiments with elan and interest. The problem which examined the cleaning power was particularly successful. Unfortunately, the experimental results were not sufficiently conclusive, which was slightly demotivating for the students. The average values of the questionnaires' subscales work out to be natural, i.e. 4 (meaningfulness 4.12, possibility of choice 4.18, enjoyment 4.89), with corresponding median values. However, more significant agreement and disagreement could be seen at the statement "I enjoyed this activity," where the average value of agreement was 5.38 with median 6, while the claim "I found this activity boring" had the average value of 2.32 and median 2.

The selected activities of the unit Polymers around us were gradually realized with 264 students of lower-secondary schools and upper-secondary schools. Simpler activities related to physical properties of plastics and separating plastic trash were meant for the primary school students, the more demanding activities for students of higher years of secondary schools which had quite a lot of experience with laboratory work. On the other hand, it turned out that it's exactly these students, mostly used only to classical teaching, who usually have some problems with creating hypotheses and expressing the assumptions before starting their own experimental activity. Some activities met huge success, like sticking a wooden skewer through a balloon without popping it, but others were less interested for the students. Exploring the properties of known plastic samples, which required systematic work, was more interesting for the younger students, while the older ones approached it sluggishly and didn't get to exploring an unknown plastic sample in the same laboratory exercise. The evaluation of the questionnaire shows that while the average value of the meaningfulness and importance subscale has the value of 3.21 (in other words, the students perceived these activities as slightly below average), the statement "I believe this activity could have some meaning for me" had median of 5. The subscale of enjoyment had the average value of 4.12 and confirmed that the students' opinion of the activities is more positive than negative. The answers related to the option to discuss the students' opinions and presumptions with their classmates showed that, on one hand, the students had almost always an option to talk with their classmates, but on the other hand, sometimes they simply explained their ideas to others or asked others to tell them theirs. The verification of this unit's activities also showed that it's quite long, and therefore it's a good idea to split it into multiple laboratory exercises. The teacher should start by stressing the importance of the explored theme in order to increase the students' motivation for their own work; the initial theoretical questions can there be resolved during the lesson, before starting the laboratory work.

The abovementioned way of verification of the IBSE activities seems to be effective. When the students were intentionally observed during these activities (which were also related to the abovementioned questionnaire surveys), we found that the activities are interesting for the students and develop their skills necessary to make the teaching more effective and apply the knowledge in real life. The activities performed and the subsequent questionnaire surveys therefore allow us to say that the students perceive the inquiry based education in a positive way but they need time to work on the activity and they need to be presented with the problem in a suitable, activising way. The teachers participating in the verification appreciated the nontraditional approach to the teaching of the given theme, focused not only on the theoretical knowledge, but also on the practical application of the theme.

Another option how to verify the effectiveness of IBSE education is a questionnaire survey based on a scheme: pre-test questionnaire – inquiry based education – post-test questionnaire. The evaluation tools were constructed based on the questionnaire IMI – Intrinsic Motivation Inventory (Ryan & Deci, 2000; Duncan & Mc Keachie, 2005) which tracks the inner motivation of the students, and the questionnaire CLES – Constructivist Learning Environment Survey (Taylor et al., 1997; Aldridge et al., 2000) which explores the student's constructivist learning environment. The questionnaire thus composed had two main parts. The first part, related to the students' relation to scientific subjects, contained 13 statements for the elementary school students, and 16 for the secondary school students; the second part, exploring the students' opinion of science and technology, contained 12 statements for the primary school students, and 16 statements for the secondary school students. The goal of the research was to find whether the implementation of inquiry-based activities in the teaching affects the students' relation to science subjects, and science and technology in general.

Our results can be clearly seen in the graphs of Figures 1-4. The pre-test results are shown in blue, the post-test results in red.

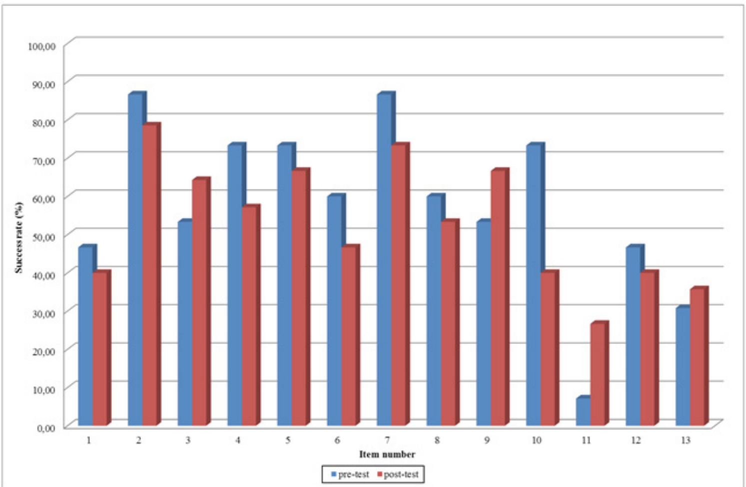

Figure 1. Approach of primary school students to scientific subjects.

Most of the students of the primary schools consider scientific subjects interesting (statement 2), less than a half considers them challenging (statement 1), and more than a half considers them fairly simple (statement 3). They are also the favorite subjects (statement 4) of more than a half of the students. Likewise, more than a half of the students believes that these subjects are important (statement 5), that they will help them in their everyday lives (statement 6), that they will help them protecting their health (statement 10), that they bring the nature closer to them (statement 8), as well as science as such (statement 9). The statement that students are more interested in things they can't explain yet, thanks to scientific subjects (statement 7), has even been marked as true by more than 70% of students. The last three questions relate to the students' interest of working in science (statement 11) or technology (statement 13) disciplines in the future, or to study scientific subjects more (statement 12). Here, the number of students is significantly lower than 50%. The number of students marking "yes" after the inquiry-based education is lower for many statements, but in the case of statements 3, 9, 11 and 13, we see stronger increase, proving that the students have understood the material better and that they have more positive approach to scientific work.

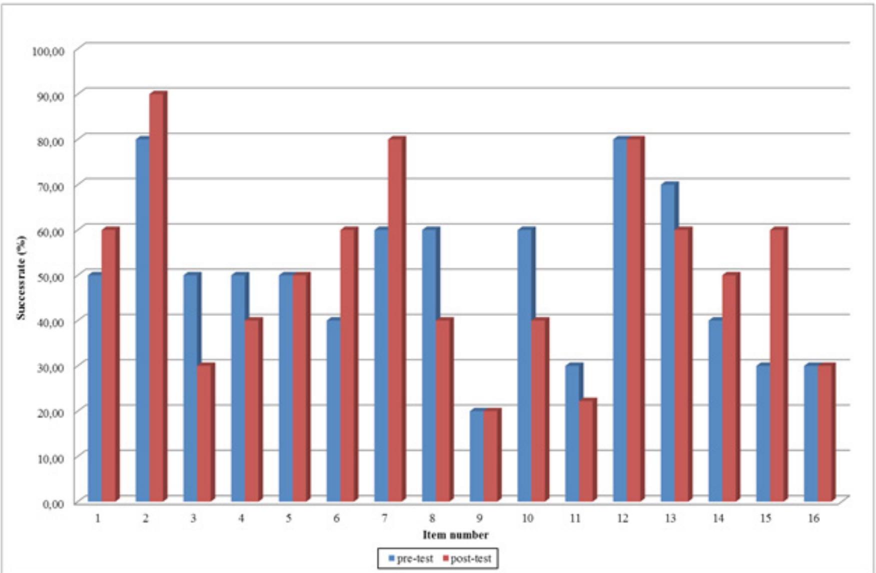

Figure 2. Approach of secondary school students to scientific subjects.

Most of the students of secondary schools also considers the scientific subjects interesting (statement 2), however, more than a half considers them challenging (statement 1), and only less than a half considers them fairly simple (statement 3).

Less than 50% of the students see scientific subjects as a perspective option of employment (statement 4), about a half considers them their favorite subjects (statement 5), and, once again, about a half would recommend them to be mandatory subjects for everyone (statement 6). More than a half of the students believe that these subjects will help them in their everyday life (statement 7), but they are much more skeptical when it comes to using the actual knowledge in practice (statement 8). Less than 20% of the students believe that the scientific subjects made them more critical and skeptical (statement 9), and less than 30% think that these subjects make them more attuned to nature (statement 11). About a half of the students think that scientific subjects make the students more interested in things they can't explain yet (statement 10). On the other hand, 80% of the students value using the scientific subject knowledge in order to protect their health (statement 13), and more than 60% value getting better knowledge about science as such. The last three questions deal with the students' interest about future work in science (statement 14) or technology (statement 16), and with their interest in more study of the scientific subjects (statement 15). The number of students is generally lower than 50% here. The number of students who chose the answer "yes" usually remains unchanged after the inquiry-based education, or it actually decreases; statements 1, 2, 6, 7, 14 and 15 see more significant increases in agreement. A surprising result is that the number of students who see the scientific subjects as challenging has increased, and the number of those who see them as simple has decreased. However, the interest in these subjects and understanding of their meaning for everyday life has grown. At the same time, the number of students with more positive approach to science and technology has increased.

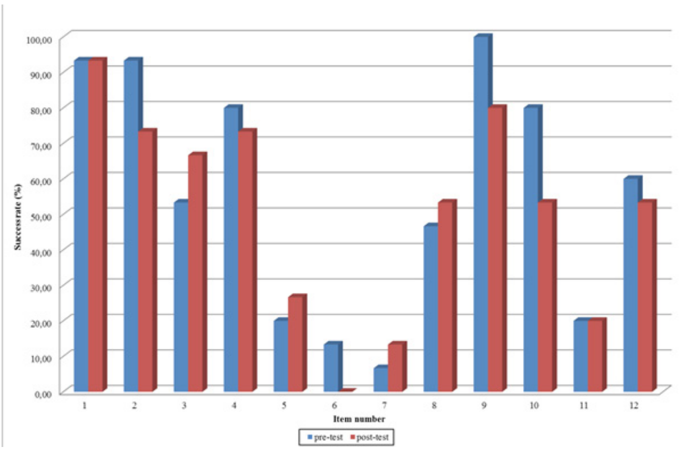

Figure 3. The opinions of the students of primary schools about science and technology.

Most of the primary school students believe that science and technology are important for the society (statement 1), that they will find cures for the current diseases (statement 2), that they will make our life healthier and more comfortable (statement 3), and that they will make our work more interesting (statement 4). On the other hand, they are very sceptical about science and technology getting rid of hunger and poverty (statement 5), that they help the poor (statement 6), and that they will solve all problems (statement 6). About a half of the students believe that science and technology are the cause of ecological problems (statement 8). Most of the students believe that all countries need science and technology (statement 9), but that they mostly help the developed countries (statement 10). Less than 20% believe that scientists must be always trusted (statement 11), but on the other hand, more than a half of the students believe in scientists' neutrality and objectivity (statement 12). For half of the statements, there are no signigicant differences between pre-test and post-test values. We can notice a more significant decrease of answers "yes" for statements 2, 6, 9, and 10; for statements 3 and 7, the number of answers "yes" has increased.

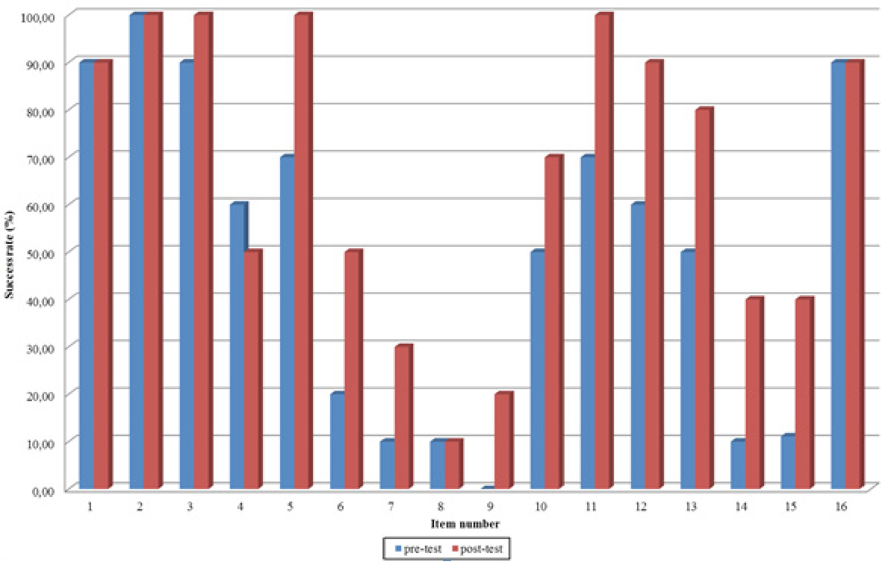

Figure 4. The opinions of the students of secondary schools about science and technology.

An overwhelming majority of secondary school students believe that science and technology are important for the society (statement 1), that they will find cures for the current diseases (statement 2), that they will give the future generations greater options (statement 3), and that they will make the work more interesting (statement 5). However, only about a half of them believes that our life will be healthier and more comfortable thanks to science and technology (statement 4). Less than a half of the students share the conviction that the contribution of science and technology is greater than their harmful effects (statement 6). The students are also very skeptical about science and technology getting rid of hunger and poverty (statement 7), that they helps the poor (statement 9), and that they will solve all problems (statement 8). About a half believes that science and technology are the cause of ecological problems (statement 10). Most of the students believe that all countries need science and technology (statement 11), but that they mostly help the developed countries (statement 12), and only a mere half of the students believe that the scientists always use the right working method (statement 13). Less than 10% believe that scientists must be always trusted (statement 14), and, likewise, only 10% of the students believe in the scientists' neutrality and objectivity. 90% of the students are convinced that the scientific theories continuously develop and change (statement 16). The pre-test and post-test values did not change much for six of the statements. There was no significant decrease in the number of answers "yes" for any statement, but there was a significant increase in statements 5-15 (with the exception of the statement 8).

As a part of the questionnaire survey, we have formed two assumptions about the effect of inquiry-based activities on students' opinion on scientific subjects, science and technology. The assumption that inquiry based activities implemented into chemistry teaching in form of selected activities would significantly improve the students' opinion on scientific subjects was not confirmed; on the other hand, the assumption that these activities, in this scope, would positively influence the students' opinions about science and technology may be considered confirmed.

The use of inquiry-based activities in preparation of chemistry teachers

Successful IBSE chemistry teaching materials verified in the practice, i.e. methodical guidance for the teacher and worksheets for the students are good materials for training the teachers for this type of teaching. These trainings, usually meant for pre-service chemistry teachers, are done as a part of mandatory or mandatory optional education as 2-4 lesson information about the IBSE teaching. Similarly the training for in-service chemistry teachers are usually done as 1-2 lesson course that informs about this type of education.

As a part of the TEMI project, professional seminars for pre-service and in-service teachers were implemented in order to introduce them to the IBSE education in a new way (TEMI team, 2015). For the purpose of the training, the teachers were put in the roles of students. They were given activities, like students would get, and so the teachers could live through and use the inquiry on their own. Unexpectedly, this way of teaching made them interested, the participation in the seminars was steadily growing, and the teachers realized on their own example, how much this new approach brings to their teaching. There have been 12 two-day workshops in total for six groups of teachers of scientific subjects, mainly chemistry and biology, in the Czech Republic; 161 teachers in total have participated (Čtrnáctová et al., 2015).

During each workshop, the teachers were given 10-12 inquiry-based activities that put them into the role of students; then, they solved the activity in question under the guidance of a lecturer. The results of the solution and using the activities in practice were subsequently summarized in the closing discussion. An inseparable part of the workshop was also a show, usually in the form of "magician show" full of magical experiments.

In the workshops, the teachers also got acquainted with the 5E learning cycle, with teaching based on gradual release of responsibility to the students, with finding and creating "mysteries" that can be used for inquiry based teaching, with suggesting and using of various "showmanship" technics, and, most of all, with the use of inquiry based approach and creation of suitable tasks for their own teaching

The individual "mysteries" were presented by lecturers; while some were the employees of the Faculty of Science at Charles University, others were actual teachers of primary and secondary schools who already went through the training in the previous professional workshops. The lecturers and the teachers, and also the teachers among themselves, discussed each of the problems and tried to modify it and to use it in their own teaching in a suitable way.

At the end of each day of the two-day workshop, the teacher noted their opinions and attitudes about the implemented program and inquiry based education as such using a questionnaire survey.

From the questionnaire surveys, we have found that 81% of the teachers who participated in the professional seminars would like to try the IBSE approach in their classrooms. The answers to the question "What do you think this workshop has given you?" were as follows: 65% of the teachers got the motivation to innovate their teaching, 63% got new tools for their teaching, 55% got new approach to teaching, 52% understood the principles of inquiry based education better, and 52% got useful practical examples.

The Figure 5 graphically shows the satisfaction of the teachers related to the applicability of the materials in their teaching, their enjoyment of the seminar, the importance of this problematics in teaching, and their interest in the IBSE approach and the mentioned teaching themes.

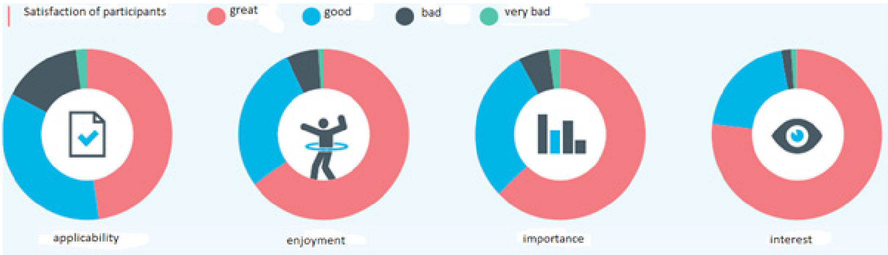

Figure 5. The results of the questionnaire survey – satisfaction of participants.

As a part of the training and subsequent questionnaire survey, it was found that the application of inquiry based education in the school practice, dominantly dependent on the willingness and cooperation of the teachers, is, exactly because of the obtained interest and engagement of the teachers, possible and successful in practice (TEMI team, 2015).

Conclusion

The use of inquiry-based science education (IBSE) in practice rests on satisfying four conditions: the curricular documents must create a space for such teaching, there must be suitable materials for it, the students must be able to accept this way of teaching and the teachers must be able to teach in this way.

As for the teachers, the project ESTABLISH (2010-2014) performed questionnaire surveys to determine whether our teachers have encountered the IBSE method and whether they consider it suitable for science teaching. The results of the surveys showed that teachers are not very well informed about IBSE. For this reason, the main problem of IBSE's application in the Czech Republic can be said to be the insufficient preparation of the teachers for it. However, this requires truly high-quality educational materials for inquiry based education that were already practically verified in real school practice. This is why we gave considerable attention to the verification of these materials. The verification of inquiry based activities in chemistry teaching showed both advantages and problems with this type of teaching. Some problematic parts of the application of IBSE can be considered to be the high time and material requirements for teacher preparation. Also, the teachers were originally pessimistic when encountering the passivity of the students and their reluctance to cooperate and work on their own. However, when IBSE was gradually and systematically implemented in the lessons, the students got gradually used to this way of teaching. The reason for this situation is the classical way of teaching that is prevailing at our schools; the students are not used to thinking, they have a problem with discussing a given theme because they can't listen to their classmates' opinions. For this reason, the teachers eventually came to appreciate the inquiry based approach as a very effective way of teaching that forces the students to think on their own, to solve problems, to discuss with their classmates, to use arguments and to draw conclusions. The experiments that were a part of the inquiry based activities strongly motivated the students and contributed to the development of their experimental skills. It is undoubtable that the students gain more permanent knowledge via being active, and it also develops the students' key competencies.

Even though the verification of inquiry-based activities with the students didn't confirm any significant influence on the students' relation to science subjects, mainly because these activities were only applied in short span of time, the results of the research confirmed the interest of the students in this way of teaching, which was also shown in the change in the students' opinions about the importance of science for life. The students started seeing the subject of chemistry as easier to understand. However, in order to successfully implement the inquiry-based activities into teaching, the teaching itself must be precisely designed, created, and prepared. Another important fact is that inquiry based approach and the classical approach can complement pretty well in real teaching. If it's necessary to reach the lesson's goals, classical lecture, explanation, experimental demonstrations etc. can still be used, and when the students need to acquire important terms that need to be understood, it's suitable to use the inquiry based education method.

Thanks to the irreplaceable part the teachers play in the IBSE teaching, we have decided to make use of the verified IBSE activities and we have decided, as partners of the TEMI project (2013-2016), to organize a training system for in-service and pre-service teachers that would give the teachers new knowledge and skills, allow then to connect more with their students, and give them new resources and support necessary for effective introduction of this teaching method to their classrooms. The preparation and realization of this training was done in the way of identifying a scientific "mystery" and having the teachers actively work using inquiry and discovery. This is why this contribution is focused mainly on the ways how to implement this training and on its results.

Acknowledgements

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Evaluation and Comparison of Newly Designed IBSE oriented MBL Activities and of Work with MBL Systems by Slovak and Czech Students

Introduction

Sensors around us

We have been witnesses of the rapid development of electronics and computer technology in recent decades, until these technologies have become stage by stage an integral part of our lives. Some people may not be aware how this kind of technology is more and more becoming normal, but today's children cannot imagine what was it like "before". They are born into a world full of machines, computers, sensors and technology. Even behind the boarders of developed countries children are familiar with cell phones, tablets, smart phones or other similar type of technology. It is natural for them to rotate tablet or smart phone and see that the screen responds to the rotation, which could not happen without installed gyro sensor; the screen brightness adjusts itself according to light conditions or appropriate camera mode activates due to sensor of light intensity. Light intensity sensors are also part of the corridors' equipment of many houses and buildings; approach sensors (in other words, motion sensors) have been for a long time a part of different terminals or at the urinals, that react on the presence of an object in close proximity of a sensor. With the support of these sensors there are being developed interesting (and bizarre) applications, for example Water Level or Hang Time (How much will you jump?) (Stange, 2011). Some of these smart phones (or smart watches) even have the possibility to measure the temperature or pressure and are able to determine, among other things, altitude (Václavík, 2014). The same natural presence of sensors and instrumental technique is also in science and research. The sensors and adequate instrumentation are used not only for research and monitoring some hardly visible change (e.g. detector response radiation), but also to characterize the prepared materials and substances and it is practically impossible to publish research results without the use of sensors (pH, pressure, conductivity, ...) or adequate instrumental techniques (gas chromatography, spectrometry, ...).

School laboratory

Despite the situation in real life and real laboratory, students still often work out experiments the way they were done decades ago. The old methods have definitely their place in school laboratory practice, because it can develop the skillfulness of the students, but some experiments can be done similar to real laboratory practice, with the use of instrumental technique, that may be closer to today's students that are familiar with various technologies. School experimental (instrumental) systems, called also probeware, are not new in school laboratories, nowadays even the acquisition price is quite acceptable for the school management, but there are other obstacles that obstruct fully employment of probeware in school laboratory practice. This contribution will focus on student's attitude to probeware microcomputer-based laboratory (MBL) and activities newly designed in international project COMBLAB.

Microcomputer-based laboratory, MBL

Microcomputer-based laboratory is a way how the school laboratory practice is done – not the classical way using subjective methods of determination for example equivalence point, but using instrumental techniques that can easily visualize observed phenomena by displaying specific quantity by a graph, table or just a value. For school laboratory practice a special probeware (equipment) was prepared. It is a set of various sensors which can be connected through a common interface to a data collecting device, such as PC, datalogger, tablet, smartphone. Unlike professional laboratory devices it is quite small, mobile, robust, variable for numerous kind of sensors so that it can be used in different school subjects, it has a simple control and data treatment and easy maintenance.

The history of MBL is quite long, in USA there were first attempts to use micro-computers in natural-science education at the end of 1970s (Hood, 1994), followed by researches on quantitative, such as technical aspects (e.g. Lam, 1983; Tinker, 1985) and also qualitative pedagogical aspects (e.g. Thornton, 1986). There were researches, mostly in physics education, comparing classical and instrumental design of experiment which revealed that MBL develop abstract thinking (Thornton & Sokoloff, 1990, Hamne & Bernhard, 2001) and increases students' scientific competencies (Tinker, 1996). Obvious advantages of MBL are the quick and on-line response of the instrument, fast data treatment and immediate feedback for students that see graphical output of the phenomena that is happening in the very surrounding of the sensor.

Project COMBLAB

Project COMBLAB (acronym derived from Competencies for Microcomputer-Based Laboratory), titled The acquisition of science competencies using ICT real time experiments, was a European project where the researchers from six following universities belonging to five European countries were involved: (i) Universitat Autònoma de Barcelona (Spain), (ii) Charles University in Prague (Czech Republic), (iii) University for Teacher Education Lower Austria, Vienna (Austria), (iv) Universitat de Barcelona (Spain), (v) University of Helsinky (Finland) and (vi) Matej Bel University in Banská Bystrica (Slovakia). In the years 2012-2014 the project main aim was to design and implement the research based learning materials for students and teaching materials for teachers on the background of MBL. The subjects of the project interest were Physics, Chemistry and Biology and after finish of the project the activities are still disseminated via teachers' courses or laboratory courses for secondary school students that are held at some partners' universities laboratories. There were developed 24 activities on chemistry, 11 on biology and 12 on physics in all language versions of the countries participating in the project. Revised didactic sequence of prepared worksheets was presented by Tortosa Moreno et al., 2013a, Šmejkal et al., 2013 and Eva Stratilová Urválková et. al, 2014.

Objectives

According to situation in real scientific laboratory, COMBLAB project wanted to contribute with tools for science teachers to enhance scientific, ICT and transversal competencies in secondary school students. On that account research based teaching materials with revised didactic sequence were developed. The emphasis was put on context of each activity and inquiry-based elements so that students do not just work out the experiment after cook-book instructions. There were many questions that arouse before and during the project: for example, Are students motivated for laboratory work with MBL or are they saturated by computer technology?, Is the work with MBL complicated for students?, How do students perceive each activity – are they motivated to perform particular activity?, What are the variables that influence students' motivation to work out the experiment?, and many others. To answer satisfactory these questions two instruments for evaluation of prepared materials were used: (i) questionnaire for motivation orientation and (i) questionnaire for activity evaluation. Some results were also already presented, for example, by Tortosa Moreno et al., 2013b or Skoršepa et al. 2014.

Methods

In this study 18 newly designed computer aided laboratory activities (Table 1), 12 for Chemistry and 6 for Biology, were designed and tested with secondary school students in Slovakia and the Czech Republic.

Table 1. The list of implemented activities (CHEM = Chemistry, BIO = Biology).

	Activity
CHEM 01	CO_2 in the Sea. *(pH measurement)*
CHEM 02	Antacids and the stomach acid *(Acids and bases, neutralization)*
CHEM 03	The Greenhouse problem *(Spectrophotometry)*
CHEM 04	Fire extinguisher *(Gas production, gas pressure)*
CHEM 05	Acid Rains *(Acids and bases, neutralization)*
CHEM 06	Cleaning Liquid *(Acids and bases, neutralization)*
CHEM 07	Red or white? Sweet or dry? *(Acidity of wine)*
CHEM 08	Quality of water: How to determine chloride content in a tap water?
CHEM 09	What dye is present in the drink? *(Spectrophotometry)*
CHEM 10	What is the content of the dye in the drink? *(Spectrophotometry)*
CHEM 11	Gas chromatography
CHEM 12	Redox titration: How to determine hydrogen peroxide
BIO 01	The life of Yeast. *(Fermentation)*
BIO 02	Photosynthesis
BIO 03	Eutrophication
BIO 04	What are the best conditions for seeds to germinate? *(Seed Germination)*
BIO 05	What makes your heart stand still? *(EKG)*
BIO 06	Blood Pressure, do you know what it is? *(Blood Pressure)*

The uniform structure of the activities was prepared collaboratively by all participating international partners and can be seen in Figure 1. The background for the structure was inspired by the previous research-based frameworks suggested by Pintó et al. (2010), Espinoza & Quarless (2010) and Tortosa (2012). All activities are designed to be student-centered reflecting the IBSE principles. Some parts of them also follow the well-known POE sequence (Predict – Observe – Explain) suggested by White & Gunstone (1992).

The attitudes and opinions of the students participating the courses were collected through newly designed tool (a 20-item questionnaire) and statistically evaluated. The courses attended totally 664 Czech and Slovak secondary school students (mean age 16.97; SD 1.20) from 15 participating schools (11 in the Czech

Republic, 4 in Slovakia). The most of the implementations (919) were realized in the university laboratories (Charles University in Prague, Czech Republic and Matej Bel University in Banská Bystrica, Slovakia). Totally, 1408 (476 SVK + 932 CZE) evaluations have been performed as part of the students participated and evaluated more than one activity. In the questionnaire, students evaluated quality of the activity and work with MBL system. For evaluation purposes, a special tool (a 20-item questionnaire) has been administered to the students after performing each activity (implementation).

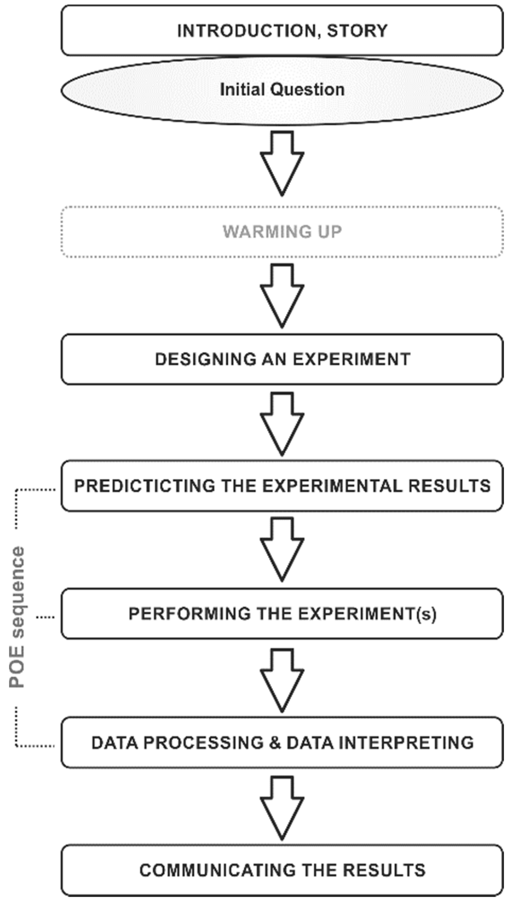

Figure 1. The uniform structure of the designed activities (The POE sequence is also depicted).

For this study, seven following questionnaire items were selected to be discussed in more detail: (Item 01) I found the activity interesting and motivating; (Item 02) The instructions were clear to me; (Item 03) Overall, how satisfied were you with the activity; (Item 04) It was easy to set up the experimental equipment, (Item 05) It was easy to work with the computer system; (Item 06) I needed my Teacher's help to perform the experiment and (Item 07) I would appreciate more frequent use of MBL in my classes. All the items are positive declarative clauses where students expressed their level of agreement on 4-point Likert scale – items 1, 2, 4 - 7 (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree) or 6-point Likert scale – item 3 (☺☺☺ - ☺☺ - ☺ - ☹ - ☹☹ - ☹☹☹). The data were processed by several statistical methods, such as descriptive statistics, analysis of frequencies and comparative analysis. The significance was determined by non-parametric Mann-Whitney U test or Kruskal-Wallis H test at 0.05 level. The correlation between some items has been determined using Pearson correlation coefficient.

Results

Evaluation of activities

ITEM 01: I found the activity interesting and motivating.

ITEM 02: The instructions were clear to me.

ITEM 03: Overall, how satisfied were you with the activity?

The frequency analysis of the item 01 showed that, in overall, the activities were evaluated positively by participating students as the average mark was 1.6/4, which means that 93 % of students consider the activities as interesting and motivating and only 7 % of students considered the activities as non-interesting. The result indicates that, at least, warming-up part is adequately designed and students are able to identify themselves with the objectives of the activities and with the activities scheme. The result also indicates that IBSE design of the activities is not drawback for students and a prerequisite of motivation of students using the "warming up" part and IBSE approach has been carried out. Surprisingly, the significant differences have been shown comparing the Czech and Slovak students (U = 155 207.000; z = -9.569; $\boldsymbol{p = .000}$; MR_{Czech} = 757.50, MR_{Slovak} = 564.57). Slovak students reported higher involvement in the activities as ca 65 % reported the activities to be very interesting and 32 % to be interesting. In the case of Czech students, majority of 54 % considered activities as "just" interesting. About 37 % of Czech students considered the activities as very interesting. Ca 9 % of Czech students (ca 5 % higher than in Slovakia) reported the activities as not very interesting or boring. The statistical analysis also showed an influence of particular activity performed by the students, site where the activity takes place (university or school) and school/chemistry teacher of participating students. As the Czech and Slovak students performed, to some extent, different activities, and Slovak students performed the activities only at university, a reduced set of evaluations only of Czech and Slovak students implementing the same activities at university only was taken into account. Although this reduced set has 188 students (155 Slovak, 33 Czech), it also shows significant difference between Czech and Slovak students as Slovak students evaluated activities more positively.

The clarity of the instructions for the activities (Item 2) was also evaluated very well as the instructions were clear for ca 83 % of Czech students and 98 % of Slovak students. Again, there is a significant difference between Czech and Slovak students (U = 136 844.000; z = -12.386; $\boldsymbol{p} = \mathbf{.000}$; MR_{Czech} = 777.79, MR_{Slovak} = 525.99), nevertheless in this case, the reduced set of evaluations with Czech and Slovak students implementing the same activities at Czech and Slovak side and performed at universities does not show a significant difference between Czech and Slovak students. It is expected result because there is no reason for differences in clarity of the instructions and majority of differences in clarity can be clearly attributed to the differences between particular activities (see later).

The overall satisfaction with the activities (item 3) shows similar pattern as in the case of item 1 (motivational aspect of the activity). Although majority of Czech (93 %) as well as Slovak (98 %) students reported high satisfaction with the activities, in the case of the Czech students, the overall satisfaction with the activities is more shifted to medium values. While majority (76 %) of Slovak students rated the activities by the highest possible mark (☺☺☺) on sixth point scale, Czech students were more sceptical voting the most the second mark on the scale (☺☺ - 43 %). Also, almost one quarter (23 %) of Czech students was shifted to neutral position evaluating the activities. Hence, there was a statistically significant difference between Czech and Slovak students (U = 110 398.000; z = -14.757; $\boldsymbol{p} = \mathbf{.000}$; MR_{Czech} = 772.92, MR_{Slovak} = 470.43). This significant difference was also observed in reduced set of evaluations (U = 2 954.000; z = -5.578; $\boldsymbol{p} = \mathbf{.000}$; MR_{Czech} = 272.17, MR_{Slovak} = 182.99).

Comparison of the individual activities also showed statistically significant differences among them (Item 1: $\chi 2(4) = 118.269$; $\boldsymbol{p} = \boldsymbol{.000}$; Item 2: $\chi 2(4) = 182.197$; $\boldsymbol{p} = \boldsymbol{.000}$; Item 3: $\chi 2(4) = 172.817$; $\boldsymbol{p} = \boldsymbol{.000}$). Although the Slovak students tend to be more positive in evaluation, which can influence success of activity in evaluation, on the basis of additional information provided by students in their comments and experience of teachers from evaluations, the most favourite activities among students could be identified (Item 03). They were activities CHEM 02 (Antacids), CHEM 04 (Fire extinguisher), CHEM 05 (Acid rains) and CHEM 06 (Cleaning Liquid). All of these activities gathered over 70 % in highest mark (☺☺☺). The activities CHEM 02 and CHEM 04 were also very positively evaluated with respect to the clarity of the instructions as majority of students evaluated them very positively (78 % and 77 %, respectively). In this category, also activities CHEM 03 (Greenhouse problem), CHEM 05 (Acid rains), BIO 05 (ECG) and BIO 06 (Blood pressure) were rated very positively (all over 60 % of the highest rankings). The most successful biology activities showed to be BIO 05 and BIO 06 (47 % and 64 %, respectively), probably due to the fact that they are oriented to human body, which is theme very familiar to the students and also due to high clarity of the instructions and high reproducibility of the results. Surprisingly, the highest motivational effect has been identified at activity CHEM 11 (Gas chromatography – the highest ranking provided by 75 % of students). The reason probably is that in this activity, students solve a criminal case (presence of methanol in alcoholic drink) using modern method, similarly to CSI cases (Wikipedia, 2017), for example. Unfortunately, the analysis takes time and it is a little bit boring to be rated higher in overall evaluation. The other motivational activities are the same as the activities rated very positively in overall evaluation. This result indicates that there is some correlation between motivational potential (Item 01) of the activity and its positive overall evaluation (Item 03) as shown in Table 2.

*Table 2. Correlation matrix (Pearson) for Items 01 - 03. (**- correlation is significant at 0,01 level (2-tailed)).*

	Item 01	Item 02	Item 03
Item 01	1		
Item 02	0,38**	1	
Item 03	0,53**	0,39**	1

Therefore, if students are adequately motivated, they are more satisfied with activity and, vice versa, it is reasonable not to underestimate the motivational ("warming up") part of the activity. On the other hand, the instructions clarity (Item 02) does not correlate very much with the overall satisfaction with the activity (Item 3; see Table 2), which indicates that more complicated instructions usually provided in the case of IBSE oriented activities are not necessarily complication for students in implementation of the activity and the motivation can play more important role and, to some extent, better motivation can partially compensate more complicated instructions (if it is necessary).

On the tail of the activity rankings, the more open IBSE activities with unclear instructions and, especially, activities with problems with reproducibility of results were positioned. They were the activities CHEM 12 (Redox titration - problems with software during titration), CHEM BIO 03 (Eutrophication - "very" open IBSE, reported relative lack of motivational aspects), BIO 02 (Photosynthesis – low reproducibility of results) and BIO 04 (Germination - low reproducibility of results). Surprisingly, activities focused on spectroscopy (CHEM 03, CHEM 09, CHEM 10), which was a new and not very simple theme for the students in evaluation, were also evaluated very positively and their rankings were also very positive as overall satisfaction and motivation exceeded 80 % and, at least 30 % of students reported highest evaluation mark in overall satisfaction. Despite the fact that some activities are less successful than the others, also these activities were, in overall, evaluated positively, gathering in all the cases more than 50 % of positive or neutral marks. It indicates, as some activities would certainly deserve some corrections, all of them provide sufficient motivational potential, clear instruction and can be implemented in secondary schools with respect to practicability and the motivation of students. The comparison of results for the individual activities can be found in Table 3.

Table 3. Comparison of the students' evaluation of the individual activities (Item 03 – Overall satisfaction with the activity).

ACTIVITY	☺☺☺	☺☺	☺	SATISFIED	☹	☹☹	☹☹☹	UNSATISFIED
CHEM 01	50%	45%	10%	**100%**	0%	0%	0%	**0%**
CHEM 02	78%	28%	12%	**100%**	0%	0%	0%	**0%**
CHEM 03	60%	11%	13%	**100%**	0%	0%	0%	**0%**
CHEM 04	79%	34%	9%	**98%**	2%	0%	0%	**2%**
CHEM 05	77%	47%	15%	**98%**	0%	0%	2%	**2%**
CHEM 06	71%	64%	4%	**96%**	0%	0%	4%	**4%**
CHEM 07	43%	45%	13%	**96%**	4%	0%	0%	**4%**
CHEM 08	29%	28%	19%	**96%**	0%	4%	0%	**4%**
CHEM 09	36%	11%	29%	**99%**	0%	1%	0%	**1%**
CHEM 10	30%	34%	41%	**95%**	1%	4%	0%	**5%**
CHEM 11	36%	47%	14%	**96%**	4%	0%	0%	**4%**
CHEM 12	22%	64%	15%	**78%**	15%	7%	0%	**22%**
BIO 01	45%	37%	16%	**98%**	1%	0%	2%	**3%**
BIO 02	28%	43%	18%	**89%**	5%	5%	0%	**11%**
BIO 03	11%	39%	39%	**89%**	4%	3%	4%	**11%**
BIO 04	34%	34%	24%	**92%**	5%	2%	1%	**8%**
BIO 05	47%	37%	12%	**97%**	2%	0%	0%	**3%**
BIO 06	64%	16%	14%	**95%**	2%	2%	1%	**5%**

Evaluation of MBL approach

ITEM 04: It was easy to set up the experimental equipment.

ITEM 05: It was easy to work with the computer system.

ITEM 06: I needed my Teacher's help to perform the experiment.

The attitudes of students to MBL approach used in implementation of the described activities was studied using Items 04 – 06 and it was followed whether it was easy to set up the experimental system (Item 04), whether it was easy to work with MBL system (Item 05) and whether some teacher´s help was necessary during the activity implementation. The results of the evaluation indicate that, in overall, for majority of students in evaluation, it was very easy (51 %) or easy (38 %) to set up the MBL system and very easy (57 %) or easy (33 %) to work with the MBL system. Only 11 % of students reported problems with set up of the equipment and 10 % considered work with MBL system to be complicated. It indicates that students consider handling of the MBL systems as simple and it does not seem to be a drawback in implementation of MBL in schools. Slovak students consider set-up of MBL systems as more simple than Czech students, as can be demonstrated by Mann-Whitney U test made for reduced set of evaluations of students and activities implemented in Slovakia as well as in the Czech Republic and at university (as Slovak students implemented the activities at university only) - (U = 2 030.500; z = -2.224; $\boldsymbol{p = .026}$; MR_{Czech} = 110.47, MR_{Slovak} = 91.10). Nevertheless, no statistically significant difference between Czech and Slovak students was observed for Item 5 (work with MBL systems). The small difference between Czech and Slovak students can be explained by higher reported motivation of the Slovak students and higher effort which they want to put into the activity implementation. The more important factor influencing work with MBL is the particular activity (Item 04: $\chi 2(4) = 119.744$; $\boldsymbol{p = .000}$; Item 05: $\chi 2(4) = 176.077$; $\boldsymbol{p = .000}$). Analysis of answers of questionnaire shows that problems with set-up and measurement can happen in the case of activities where titration is made (see Table 4 – CHEM 07, CHEM 08 and CHEM 12) and where the more complicated, in comparison to "time-based" measurements, manual set-up of axes and manual input of volume are necessary. It can cause some issues and problems, for example with not correctly entered values, changes of scale of axes etc. leading to negative reports of students.

In the case of spectroscopic measurements (CHEM 03, CHEM 09 and CHEM 10), more rarely, students also reported some issues in set-up and measurements with MBL system, mostly connected to unwanted clicks in the control program accompanied with change of the screen of the program. These issues cannot be simply ignored as they are connected to nature of the measurement, nevertheless, teacher should put an exceptional effort to explain prior the experiment students all the aspects of the MBL system set-up and measurement in the case of titrations and spectroscopy measurements to focus later only on taught phenomena.

Table 4. Comparison of the students' evaluation of set-up and work with MBL system (Items 04 and 05) for the particular activities.

	Very easy		Easy		Difficult		Very difficult	
ACTIVITY	ITEM 04	ITEM 05	ITEM 04	ITEM 05	ITEM 04	ITEM 05	ITEM 04	ITEM 05
CHEM 01	30%	90%	20%	10%	40%	0%	10%	0%
CHEM 02	60%	66%	40%	34%	0%	0%	0%	0%
CHEM 03	40%	33%	53%	53%	7%	13%	0%	0%
CHEM 04	70%	77%	28%	23%	2%	0%	0%	0%
CHEM 05	60%	70%	38%	28%	2%	2%	0%	0%
CHEM 06	75%	92%	25%	8%	0%	0%	0%	0%
CHEM 07	36%	39%	36%	41%	25%	16%	2%	5%
CHEM 08	34%	25%	32%	32%	21%	21%	13%	21%
CHEM 09	43%	53%	43%	35%	13%	9%	2%	3%
CHEM 10	39%	52%	44%	33%	17%	13%	0%	1%
CHEM 11	39%	68%	54%	32%	7%	0%	0%	0%
CHEM 12	21%	22%	21%	19%	21%	37%	36%	22%
BIO 01	48%	51%	45%	43%	5%	3%	2%	3%
BIO 02	44%	47%	48%	43%	8%	9%	0%	1%
BIO 03	43%	36%	49%	49%	7%	16%	1%	0%
BIO 04	63%	59%	32%	35%	2%	5%	3%	1%
BIO 05	60%	72%	33%	25%	6%	2%	1%	1%
BIO 06	57%	69%	32%	20%	4%	3%	7%	8%

Despite relative simplicity in set-up and measurement with MBL system, more than half of participating students reported some help necessary provided by their teacher (Item 06; see Table 5).

Table 5. Amount of help provided by teacher reported by students (Item 06).

	VERY HELPFUL	HELPFUL	MARGINAL HELP	NO HELP
CZECH STUDENTS	20%	47%	22%	11%
SLOVAK STUDENTS	4%	35%	37%	24%

Slovak students stated statistically significant less help demand than Czech students (U = 284 984.000; z = 10.531; $\boldsymbol{p}$ **= .000**; MR_{Czech} = 612.40, MR_{Slovak} = 837.21), which was also observable in the reduced evaluation set (common activities made at university; (U = 1 776.500; z = -2.930; $\boldsymbol{p}$ **= .003**; MR_{Czech} = 118.17, MR_{Slovak} = 89.46). Although it seems, that Slovak students worked more autonomously, surprisingly, the Czech and Slovak teachers who led the activities report similar and not statistically significant difference in the help provided to students and, help provided by Czech teachers well corresponds to the help reported by their students. Hence, we speculate that higher reported motivation of Slovak students just underestimated their feeling of help provided by their teachers. The statistical significant differences among the activities were also observed ($\chi 2(4)$ = 235.312; ***p = .000***). The reports of students regarding the Item 06 with respect to performed activities are summarized in Table 6. From this point of view, the most demanding activities are the activities based on titrations (CHEM 07, CHEM 08 and CHEM 12) again and, to smaller extent, spectroscopic activities (CHEM 03, CHEM 09 and CHEM 10).

Table 6. Amount of help provided by teacher reported by students (Item 06) sorted by activity.

ACTIVITY	VERY HELPFUL	HELPFUL	MARGINAL HELP	NO HELP
CHEM 01	20%	70%	0%	10%
CHEM 02	3%	41%	41%	14%
CHEM 03	33%	47%	20%	0%
CHEM 04	6%	23%	26%	45%
CHEM 05	2%	68%	17%	13%
CHEM 06	4%	25%	38%	33%
CHEM 07	28%	45%	20%	7%
CHEM 08	29%	54%	14%	4%
CHEM 09	12%	54%	25%	10%
CHEM 10	20%	57%	20%	3%
CHEM 11	18%	71%	4%	7%
CHEM 12	46%	43%	7%	4%
BIO 01	13%	48%	29%	10%
BIO 02	33%	41%	15%	10%
BIO 03	9%	59%	29%	3%
BIO 04	12%	37%	31%	19%
BIO 05	4%	27%	36%	34%
BIO 06	10%	33%	40%	17%

In all these cases, only a minority of students reported that no or less help is necessary during the activity implementation. Nevertheless, also some of the successful activities were, to some extent, relatively demanding, for example CHEM 11 (Gas chromatography) or CHEM 05 (Acid rains). In the case of biology activities, the BIO 02 (Photosynthesis) and BIO 03 (Eutrophication) activities were the most demanding with respect to help provided to students by teacher (see Table 6). On the basis of students´ comments, the help provided to students by teachers was divided into four groups. The groups were the following: (a) Technical problems connected to MBL set-up and control (hardware and software problems); (b) "Laboratory work problems" (preparation of solutions, how to use a pipette etc.); (c) Theoretical problems (calculations, theoretical background etc.) and (d) "Other problems" ("Where is WC?" etc.). Quantification of the answers allowed us to estimate that majority of problems and provided help are those connected to work with MBL system (ca 59 %). Only 17 % was attributed to help connected with work in laboratory and 22 % were theoretical problems. Comparing to the "regular" laboratory course without MBL, the course with MBL seems to be ca 2 times more demanding for the teacher. It can be considered to be a problem in implementation of MBL into secondary schools and should be taken into account when organizing MBL course. The result also indicates, that problems connected to MBL approach are rather frequent and teachers must be well prepared and experienced to conduct a MBL course, which also rationalize appropriate courses for pre-service teachers in the framework of their university curriculum as well as for in-service teachers in the framework of their professional development.

Support of MBL implementation into secondary school curriculum

ITEM 09: I would appreciate more frequent use of MBL in my classes

In overall, majority (ca 86 %) of students support the implementation and more frequent use of MBL in secondary school. Slovak students are again more positive (ca 97 %) than the Czech students (ca 80 %) as the difference is statistically significant (U = 165 585.000; z = -8.683; $\boldsymbol{p = .000}$; MR_{Czech} = 700.11, MR_{Slovak} = 586.37). Although the Slovak students are more positive in evaluation of activities as well as in work with MBL systems, surprisingly, there is almost no correlation between Item 03 and Item 09 (ρ = .316, $\boldsymbol{z = .000}$) and between Item 04 or 05 and Item 09 (ρ = .155, $\boldsymbol{z = .000}$; ρ = .178, $\boldsymbol{z = .000}$, respectively). Nevertheless, despite the difference between Czech and Slovak students, the results indicate that, in overall, the attitudes of students, despite the difficulties appearing during the work with MBL systems, should not be considered as an obstacle in implementation of the MBL systems into secondary school education as the students support it.

Conclusions

A new research-based framework for computer based laboratory activities in science education has been proposed and implemented. The activities were evaluated by students very positively, more positively by Slovak students than by Czech students. The evaluation of the activities by students showed they can be considered as interesting and motivating, with clear instruction. Although all the activities gained the positive evaluation, some of them were evaluated more positively, especially those which are simple, with clear instruction, with well treated motivational part and oriented to human body and with well achievable and reproducible results (for example CHEM 02 – Antacids, CHEM 04 Fire Extinguisher, CHEM 11 (Gas chromatography) or BIO 05 (ECG) and BIO 06 (Blood pressure). On the other hand, open IBSE activity (BIO 03 - Eutrophication) and activities providing less reproducible results (BIO 04 -Germination and BIO 02 – Photosynthesis) were less successful among the students. Also set-up and work with MBL system were rated positively by the participating students as majority of them considered them to be simple. Also, majority of students support more frequent use of MBL systems in secondary school education. In this evaluation, the students preferred simple activities, the minor problems were identified in the case of activities based on titration, where the set-up and work with MBL is more complicated by the nature of the measurement and this aspect must be taken into account during preparation and implementation of the activity. Surprisingly, relatively complicated spectroscopic activities were, in general, evaluated more positively than activities based on titration and although there were more issues in set-up and measurement in comparison to the most successful activities, it seems that these activities can be implemented easier than we originally expected and they are not as demanding to teacher´s attention.

Despite very positive evaluation of the activities as well as of set-up and work with MBL systems, the course with MBL can be still considered more demanding for teachers than "regular" courses held without the MBL systems. The issues and obstacles connected to usage of MBL systems which require teacher´s attention and help, which must be provided to students, give still relatively high ration of all the help provided to students (ca more than 50 %). This drawback in implementation should be compensated by appropriate teacher´s preparation before MBL course and also rationalize existence of appropriate courses for pre-service teachers in the framework of their university curriculum as well as for in-service teachers in the framework of their professional development.

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Evaluation and Comparison of Newly Designed IBSE Oriented MBL Activities and of Work with MBL Systems by Slovak and Czech Teachers (a Comparative Study)

Introduction

Surrounded by sensors

Recently, school experimental systems slowly find their application in practice of chemistry teachers. Although it seems to be an effective tool for science education, teachers are still quite resistant to accept this instrument in their lessons. On the other hand, they must be aware of the expansion of technology into our common lives. They are not just plasma displays and smart phones or tablets that are becoming a standard even for young children, we meet various sensors almost everywhere. The sensor of proximity opens and closes the door instead of us, the light sensor enlightens dark corridors when there are people, so that it does not have to be turned on whole time, water at public places (toilets) starts flowing without touching the water tap. At households, there are thermostatic systems that control and measure the consumption of heat and energy, in the Czech Republic compulsory from year 2007. These systems work on the principle of temperature measurement through various cheap and temperature sensors, and are increasingly replacing older evaporative heat consumption indicators (Ista et al., 2014). Policemen do not check the sobriety of the driver using an orange-colored tubes filled with toxic potassium dichromate, but these tubes were replaced by analyzers with semiconductor sensors (Kubicka, 2011). In mentioned tablets and similar devices, gyro sensors and light sensors are natural thing, without them the screen would not rotate the way we are reading the screen or the brightness of display would not react on external light conditions. These sensors can then be used in newly developed applications that serve more for amusement of the user, for example Water Level or Hang Time (How much will you jump?) (Stange, 2011). In natural sciences sensors and adequate instrumentation are nowadays a must. They are used for research and monitoring some otherwise hardly visible changes (e.g. detector response radiation), but also to characterize the prepared materials and substances. It is not possible to publish some research results without the use of sensors (pH, pressure, conductivity, ...) or adequate instrumental techniques (gas or HPLC chromatography, spectra, ...). We can see that we are surrounded by various sensors, sometimes without aware of this fact. Despite the importance and high prevalence of sensors and instrumental techniques, they are only minimally reflected in science teaching at primary and secondary schools. Children that were already born in a world full of technology and they take it for granted, study nature sciences usually by performing traditional experiments, sometimes even just theoretically.

Microcomputer-based laboratory, MBL

Parallel to progress of professional instrumental devices used in research, there were efforts to develop systems that could be implemented in science education and it would illustrate specific phenomena using similar device as are used in real laboratory. The aspect of educational added value was also expected, which was confirmed in latter researches (see below). In this manner, school experimental systems were developed and used in school in so called microcomputer-based laboratories (MBL), which means rather the way how the experiment is performed – using instrumental device compared to traditional design where subjective methods are used. Today, the term MBL is sometimes being replaced by name probeware, which more refers to the equipment. When we talk about MBL or probeware, we mean sensors (pH, temperature, pressure, conductivity, spectrophotometer etc.), which are connected via a common interface to a computer, laptop, tablet, mobile phone or special logger, which serves as a control and processing/evaluating unit. These systems specially developed for school practice must have simple control and be user friendly, they must be robust and easy to maintain. An advantage is monitored and immediate display of measured data both in the form of numerical values, such as a graph, which can especially vividly demonstrate phenomena and processes that capture a certain dependence.

First attempts to use micro-computers in natural-science education were at the end of 1970s in USA (Hood, 1994), shortly after that there were publications on technical aspects (e.g. Lam, 1983; Tinker, 1985) where hardware possibilities of school devices were discussed and also publications on pedagogical aspects (e.g. Thornton, 1986). MBL was easier accepted by physics teachers and researchers, therefore we can find much more publications on MBL in physics education than in chemistry; some compared classical and instrumental design of experiment which revealed that MBL approach develops abstract thinking (Thornton & Sokoloff, 1990, Hamne & Bernhard, 2001) and increases students' scientific competencies (Tinker, 1996). The advantages of probeware are above all automatic recording and results simultaneously displayed on screen which give immediate feedback for students of measurement; collection of the data can be done with different frequencies which allows to study too fast or too slow phenomena; data can be saved and treated or revised or discussed afterwards if needed; ability to change the measurement conditions can be employed in inquiry-based learning; and the concept of the school system enables to be used in all levels of education, from primary to tertiary education. Researches also showed many pedagogical advantages of MBL (e.g. Tinker, 1986; Thornton, 1986; Mokros & Tinker, 1987; Nakhleh & Krajcik, 1991; Redish et al., 1997; Trumper, 2003): learning authority shifts from textbook and teacher to teaching tool (teacher-centered learning turns to student-centered learning); students are actively involved in the work which improves the process of learning; graphical output of experimental systems improves graphing skills; if allowed research approach students can master the experiment - formulating hypotheses, design experiments, verify hypothesis, interpret measured data; shorter collecting data gives more space for analysis, interpretation and discussion; the measurement encourages “what if” questions that indicate students’ engagement in activity; work in groups (even pair) evolves cooperation and peer learning; the technology can attract students’ interest and reduce science anxiety.

Despite its benefits, the implementation of MBL (at least) in the Czech Republic and Slovakia suffers from problems, when price and availability of probeware needn´t to be at the top of the list. The acceptation of the technology by students as well as teachers is influenced by further factors, for example (possible) technical problems or a lack of well-designed research based MBL materials (what to do reasonably with sensors). To contribute and support the implementation of MBL into schools, in the framework of European project COMBLAB, new inquiry-based MBL activities on chemistry, biology and physics were designed and developed (Tortosa Moreno 2013a, Stratilová Urválková et al., 2014) and, the courses on MBL implementing the newly developed activities were held for Czech and Slovak teachers.

Project COMBLAB

Project COMBLAB (acronym derived from Competencies for Microcomputer-Based Laboratory), titled The acquisition of science competencies using ICT real time experiments, was a European project where the researchers from six following universities belonging to five European countries were involved: (i) Universitat Autònoma de Barcelona (Spain), (ii) Charles University in Prague (Czech Republic), (iii) University for Teacher Education Lower Austria, Vienna (Austria), (iv) Universitat de Barcelona (Spain), (v) University of Helsinky (Finland) and (vi) Matej Bel University in Banská Bystrica (Slovakia). In the years 2012-2014 the project main aim was to design and implement the research based learning materials for students and teaching materials for teachers on the background of MBL. The subjects of the project interest were Physics, Chemistry and Biology and after finish of the project, the activities are still disseminated via teachers’ courses or laboratory courses for secondary school students that are held in some partners’ universities laboratories. There were developed 24 activities on chemistry, 11 on biology and 12 on physics in all the language versions of the countries participating in the project. Revised didactic sequence of prepared worksheets was presented by Tortosa Moreno et al., 2013b, Šmejkal et al., 2013 and Eva Stratilová Urválková et al., 2014.

This contribution focuses on the attitudes of teachers who were working with school experimental systems during the project COMBLAB and performed newly designed activities in microcomputer-based laboratory.

Objectives

The project wanted to contribute with tools for science teachers to enhance scientific, ICT and transversal competencies in secondary school students. Beside creating a community of teachers/researchers from different countries of the consortium to exchange experiences and good practices in the field, the core was in developing research based teaching materials for secondary and high school students and research based teacher training materials that would help teachers to implement MBL in their lessons. A revised didactic sequence was applied in most of the activities that were as well research based, which was reflected in highlighted context and inquiry-based aspects of the activities. The attractiveness of MBL approach and created activities were investigated with two evaluation instruments: (i) adopted questionnaire for motivation orientations and (ii) newly created questionnaire for activity evaluation. The results from students' questionnaires show that the work with probeware is not difficult for them, they appreciate this approach as well as the activities, although they are not used to such kind of worksheets (not a cook-book form). (Smejkal et al., 2017, Skoršepa et al, 2014) This was a positive finding that students are open to MBL and new activities, but the crucial point is a science teacher. Teachers are those who determine the content and the form of science lessons, they are the "gatekeepers" of whether students will ever work with probeware or just perform traditional test tube confirmation experiments (which is still more useful than refuse laboratory practice at all). Teachers' opinions are therefore essential for researchers: we wanted to know the attitudes of teachers on the created chemistry and biology activities and what can be improved in the worksheets; What are the teachers' attitudes and opinions on MBL technology (is it easy to work with it?); What was „the volume of help" of teachers to students needed to work with MBL?; as the Czech and Slovak teachers have similar educational history, we wanted to compare the results of Czech and Slovak teachers; and finally we wanted to find out the differences in teachers' and students' attitudes.

Methods

In this study, 18 newly designed computer aided laboratory activities (Table 1), 12 for Chemistry and 6 for Biology, were designed and tested with secondary school teachers and students in Slovakia and the Czech Republic.

The uniform structure of the activities was prepared collaboratively by all participating international partners and can be seen in Figure 1. The background for the structure was inspired by the previous research-based frameworks suggested by Pintó et al. (2010), Espinoza & Quarless (2010) and Tortosa (2012). All activities are designed to be student-centered reflecting the IBSE principles. Some parts of them also follow the well-known POE sequence (Predict – Observe – Explain) suggested by White & Gunstone (1992).

Table 1. The list of implemented activities (CHEM = Chemistry, BIO = Biology).

	Activity
CHEM 01	CO_2 in the Sea. *(pH measurement)*
CHEM 02	Antacids and the stomach acid *(Acids and bases, neutralization)*
CHEM 03	The Greenhouse problem *(Spectrophotometry)*
CHEM 04	Fire extinguisher *(Gas production, gas pressure)*
CHEM 05	Acid Rains *(Acids and bases, neutralization)*
CHEM 06	Cleaning Liquid *(Acids and bases, neutralization)*
CHEM 07	Red or white? Sweet or dry? *(Acidity of wine)*
CHEM 08	Quality of water: How to determine chloride content in a tap water?
CHEM 09	What dye is present in the drink? *(Spectrophotometry)*
CHEM 10	What is the content of the dye in the drink? *(Spectrophotometry)*
CHEM 11	Gas chromatography
CHEM 12	Redox titration: How to determine hydrogen peroxide
BIO 01	The life of Yeast. *(Fermentation)*
BIO 02	Photosynthesis
BIO 03	Eutrophication
BIO 04	What are the best conditions for seeds to germinate? *(Seed Germination)*
BIO 05	What makes your heart stand still? *(EKG)*
BIO 06	Blood Pressure, do you know what it is? *(Blood Pressure)*

The attitudes and opinions of the teachers participating the MBL courses with students or specially designed courses for teachers, which dealt with the described activities, were collected through newly designed tool (39-item questionnaire) and statistically evaluated. The courses visited totally 42 Czech and Slovak secondary school teachers (26 Czech and 16 Slovak teachers) from 23 participating secondary schools (19 in the Czech Republic, 4 in Slovakia). All the teachers participated in more than one activity, which resulted in totally 197 evaluations (74 by Czech and 123 by Slovak teachers) of the activities. In the questionnaire, teachers evaluated quality of the activity and work with MBL system. The mentioned tool (a 39-item questionnaire) has been administered to the teachers after performing each activity (implementation).

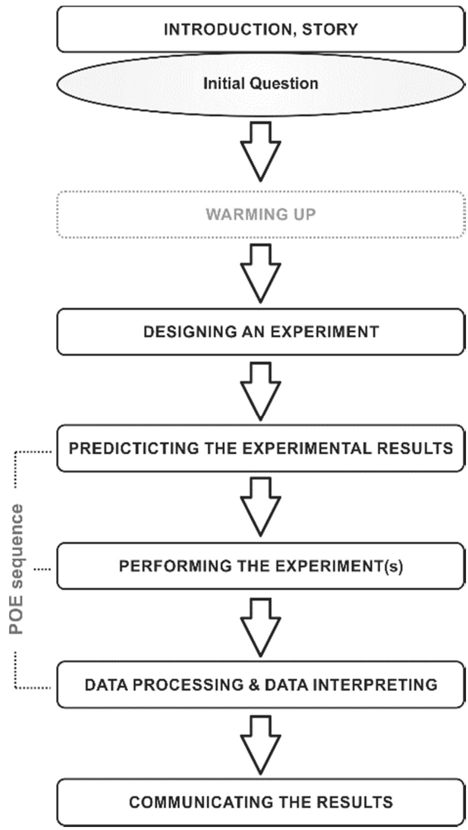

Figure 1. The uniform structure of the designed activities (The POE sequence is also depicted).

For this study, nine following questionnaire items were selected to be discussed in more detail: (Item 01) Overall, how satisfied are you with the activity as a teacher?; (Item 02) The *difficulty* of the activity is adequate to students' knowledge; (Item 03) The duration of the activity is optimal; (Item 04) The activity fits to our state educational curriculum; (Item 05) The objectives of the activity are well designed; (Item 06) Instructions for students are clear and have logical structure; (Item 07) It was easy for students to work with the computer system; (Item 08) Students needed teacher's help to comprehend the principle and the objectives of this activity and (Item 09) Students needed teacher's help to design and perform the experiments in this activity. All the items are positive declarative clauses where teachers expressed their level of agreement on 4-point Likert scale – items 1, 2, 4 - 7 (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree) or 6-point Likert scale – item 1 (☺☺☺ - ☺☺ - ☺ - ☹ - ☹☹ - ☹☹☹). The data were processed by several statistical methods, such as descriptive statistics, analysis of frequencies and comparative analysis. The significance was determined by non-parametric Mann-Whitney U test or Kruskal-Wallis H test at 0.05 level. All the Items could be supplemented by comments and/or suggestions and the qualitative analysis of the comments was also used to interpret some results of the research.

Results

Evaluation of activities

ITEM 01: Overall, how satisfied are you with the activity as a teacher?

The analysis of Item 01 showed that, in overall, the teachers participating the evaluation were satisfied with the activities. In particular, 98 % reported satisfaction, only 2 % reported slight dissatisfaction. High level of satisfaction of teaches is also proved by high ratio of teachers, 66 %, who selected the highest degree of sixth point scale of the Item 01 ("highly satisfied"), only 18 % of teachers expressed more neutral position as they reported that they are slightly satisfied. In overall, the teachers reported slightly higher ratio of satisfaction with the activities than students (95 % satisfied, 45 % highly satisfied; Šmejkal, 2017). The average mark of the Czech teachers (1 – best; 6 - worst) at the scale of overall satisfaction was 1.4, the Slovak teaches evaluated the activities by the average mark 1.7. However, the difference between Czech and Slovak teachers was not statistically significant (U = 5 084.000; z = 1.632; $\boldsymbol{p = .103}$; MR_{Czech} = 91.80, MR_{Slovak} = 103.33). As Czech students reported significantly less satisfaction (although still positive) than Slovak students (Šmejkal et al, 2017), we speculate that it can be a consequence of different conditions in the countries after the splitting of Czechoslovakia in 1993 into Czech Republic and Slovak Republic. As majority of teachers in evaluation was born and lived at least 15 years in Czechoslovakia, and after the splitting, many aspects of educations of teachers were the same or very similar for few years, all the students in evaluation were born in the isolated countries and some cultural and economic aspects changed and became different in both the countries. It probably led to the shift of attitudes as well as opinions of students of both the countries which led to the different evaluation of the activities and other aspects of the MBL course by the Czech and Slovak students. Nevertheless, the particular reasons for the observed differences would require more deep evaluation and new data and were not subject of this research. Surprisingly, the Czech teachers were significantly more positive in overall satisfaction with the activities than the Czech students (U = 37 672.500; z = -5.332; $\boldsymbol{p = .000}$; $MR_{teachers}$ = 368.28, $MR_{students}$ = 505.28), in contrast, the Slovak teachers were similarly positive as the Slovak students (U = 18 298.000; z = .714; $\boldsymbol{p = .475}$; $MR_{teachers}$ = 284.77, $MR_{students}$ = 274.06). The principal difference can be observed between the Czech teachers and students and from comments attached to questionnaires, it seems that the Czech teachers in evaluation are mostly equipped with sensors and MBL systems and they are, to some extent, more familiar to work with MBL systems and able to identify well their potential. The activities are also equipped with detailed teacher´s version, where many aspects of the activities are discussed and teachers know well what to exactly do during the activity. In the case of students, there is some ratio of uncertainty, also due to IBSE character of the activities, as they do not know the results and possible solutions, which can lead to unsuccessful implementation of the activity. Some of the students were also faced to technical problems during the activities implementation, which is another factor which led to the difference between evaluations of the activities provided by Czech teachers and students. In the case of Slovak teachers, possibly, the lack of appropriate MBL equipment and impossibility of implementation of activities in schools resulted to similar (positive) evaluation as in the case of their students. The results of evaluation of overall satisfaction with the activities are summarized in Table 2.

Table 2. Comparison of Czech and Slovak teachers′ and students′ evaluations of overall satisfaction with activities (Item 01 – Overall satisfaction with the activity).

GROUP	☺☺☺	☺☺	☺	SATISFIED	☹	☹☹	☹☹☹	UNSATISFIED
CZECH TEACHERS	70%	19%	11%	**100%**	0%	0%	0%	**0%**
SLOVAK TEACHERS	63%	11%	23%	**97%**	3%	0%	0%	**3%**
ALL TEACHERS	66%	14%	18%	**98%**	2%	0%	0%	**2%**
CZECH STUDENTS	27%	43%	23%	**93%**	4%	2%	1%	**7%**
SLOVAK STUDENTS	76%	10%	12%	**98%**	0.5%	0.5%	1%	**2%**
ALL STUDENTS	45%	31%	19%	**95%**	2%	2%	1%	**5%**

Although the overall evaluations of the Czech and the Slovak teachers showed no significant differences between them, there was significant difference observable among the particular activities ($\chi 2(6) = 58.02$; $\boldsymbol{p = .000}$). The overall satisfaction with the particular activities is shown in Table 3. We can identify that the most successful activities among the teachers were CHEM 02 (Antacids), CHEM 07 (Wine titration) and the BIO activities excluding BIO 02 (Photosynthesis). In the case of chemistry activities CHEM 06 (Cleaning liquid), CHEM 01 (CO_2 in the Sea) and CHEM 04 (Fire extinguisher), they were not evaluated so positively as other chemistry activities and their overall evaluation was shifted to the more neutral values.

Table 3. Comparison of the teachers′ evaluation of the individual activities (Item 01 – Overall satisfaction with the activity); N/E = not evaluated.

ACTIVITY	☺☺☺	☺☺	☺	SATISFIED	☹	☹☹	☹☹☹	UNSATISFIED
CHEM 01	31%	15%	46%	**92%**	8%	0%	0%	**0%**
CHEM 02	88%	12%	0%	**100%**	0%	0%	0%	**0%**
CHEM 03	50%	50%	0%	**100%**	0%	0%	0%	**0%**
CHEM 04	38%	23%	38%	**100%**	0%	0%	0%	**0%**
CHEM 05	54%	23%	23%	**100%**	0%	0%	0%	**0%**
CHEM 06	8%	8%	62%	**77%**	23%	0%	0%	**0%**
CHEM 07	80%	20%	0%	**100%**	0%	0%	0%	**0%**
CHEM 08	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**
CHEM 09	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**
CHEM 10	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**
CHEM 11	N/A	N/A	N/A	**N/A**	N/A	N/A	N/A	**N/A**
CHEM 12	67%	0%	33%	**100%**	0%	0%	0%	**0%**
BIO 01	71%	17%	17%	**100%**	0%	0%	0%	**0%**
BIO 02	50%	0%	33%	**100%**	0%	0%	0%	**0%**
BIO 03	100%	19%	0%	**100%**	0%	0%	0%	**0%**
BIO 04	76%	8%	5%	**100%**	0%	0%	0%	**0%**
BIO 05	79%	0%	13%	**100%**	0%	0%	0%	**0%**
BIO 06	84%	13%	16%	**100%**	0%	0%	0%	**0%**

This is in contrast with evaluations of students, in which the rankings of CHEM 06 and CHEM 04 were among the most attractive activities and CHEM 01 activity was evaluated also more positively. By contrast, the CHEM 07 activity was more attractive for teachers than for students, probably due to the fact that teachers are much more familiar with the titration, which is the nature of the activity and teachers were able better to adapt to all the operations and/or problems connected. Both the groups, teachers as well as students, were very satisfied with CHEM 02, BIO 05 and BIO 06 activities and not very satisfied with BIO 02 activity (Šmejkal et al, 2017). According to comments to the activities evaluation, the success of some named activities is probably a result of simplicity and reproducibility of the activities and appreciable motivational potential as these activities are based on description and function of human body. Nevertheless, the relevant comparison of all of the activities cannot be done as in cases of some activities, only few teachers evaluated them (CHEM 03, CHEM 07, CHEM 12 and BIO 03).

ITEM 02: The difficulty of the activity is adequate to students' knowledge.

ITEM 03: The duration of the activity is optimal (for particular purposes of teachers, especially with respect to "standard" duration of their lab courses).

ITEM 04: The activity fits to our state educational curriculum.

The overall positive evaluation of the activities by teachers manifested themselves also in the other items related to the evaluation of the activity, in particular in items evaluating difficulty of the activities (the average mark was 1.6 of 4-point scale), adequacy of duration of the activity (1.6) and adequacy to the state educational curriculum (1.6). Also, in this case, there were no statistically significant differences in all the items 02-04 between the Czech and Slovak teachers (Item 02: U = 4 335.500; z = -.625; $\boldsymbol{p = .532}$; MR_{Czech} = 101.91, MR_{Slovak} = 97.25; Item 03: U = 4 996.500; z = 1.280; $\boldsymbol{p = .201}$; MR_{Czech} = 92.98, MR_{Slovak} = 102.32; Item 04: U = 4 821.500; z = 1.158; $\boldsymbol{p = .247}$; MR_{Czech} = 92.53, MR_{Slovak} = 101.20). Nevertheless, there were statistically significant differences among the particular activities evaluated by the participating teachers (Item 02: $\chi 2(4)$ = 39.700; $\boldsymbol{p = .001}$; Item 03: $\chi 2(4)$ = 29.584; $\boldsymbol{p = .030}$; Item 04: $\chi 2(4)$ = 43.547; $\boldsymbol{p = .000}$). Although some activities were implemented and evaluated by only few teachers, an experience of teachers as well as researches from evaluation and some comments in questionnaires allow us, to some extent, to compare the activities from the point of view of Items 02 – 04. With respect to difficulty, teachers considered as the most appropriate majority of activities, especially CHEM 02 (Antacids), CHEM 07 (Wine titration), CHEM 05 (Acid Rains), BIO 06 (Blood pressure), BIO 04 (Germination), BIO 01 (Yeast Fermentation) and BIO 05 (EKG). All of these activities are, with respect to their difficulty, considered by teachers as very appropriate (> 40 %) and less than 10 % of teachers consider them as inappropriate (see Table 4).

On the other hand, the activities CHEM 01 (CO_2 in the Sea), CHEM 03 (Greenhouse), BIO 02 (Photosynthesis) and BIO 03 (Eutrophication) can be considered as more difficult with average mark around 2 (see Figures 2 and 3) and with majority of teachers indicating that difficulty is just appropriate or slightly inappropriate.

Duration of the activities is also mostly reported by teachers to be optimal (see Table 5). The only activities with longer duration are BIO 02 (33% of reports indicating inadequately time consuming activity) and BIO 03 (Eutrophication). On the other hand, at the edge of adequate duration, they are the activities CHEM 01, CHEM 03, CHEM 04, CHEM 05, CHEM 06, CHEM 12 and BIO 06. It indicates that the MBL course using these IBSE activities must be well prepared and organized to finish all the tasks in time and possible technical problems have to be eliminated as much as possible.

Table 4. Comparison of the teachers′ evaluation of difficulty of the activity (Item 02) for the particular activities.

ACTIVITY	VERY ADEQUATE	ADEQUATE	DIFFICULT	VERY DIFFICULT
CHEM 01	8%	54%	38%	0%
CHEM 02	72%	28%	0%	0%
CHEM 03	0%	100%	0%	0%
CHEM 04	38%	62%	0%	0%
CHEM 05	46%	54%	0%	0%
CHEM 06	31%	62%	8%	0%
CHEM 07	60%	40%	0%	0%
CHEM 12	0%	100%	0%	0%
BIO 01	58%	38%	4%	0%
BIO 02	33%	67%	0%	0%
BIO 03	0%	50%	50%	0%
BIO 04	62%	38%	0%	0%
BIO 05	58%	33%	8%	0%
BIO 06	63%	32%	5%	0%

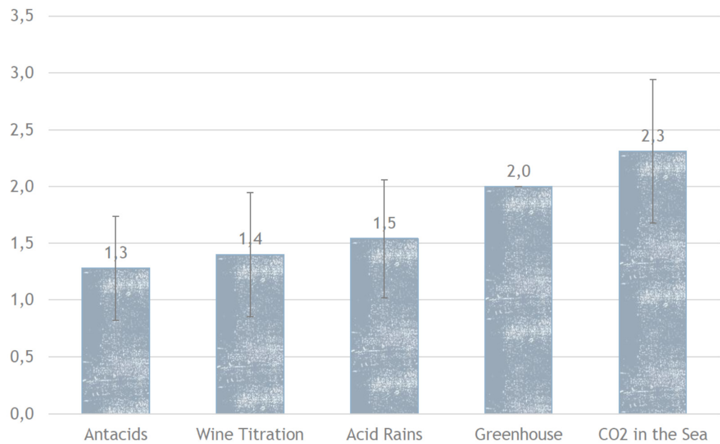

Figure 2. Mean values of teachers′ evaluation of selected activities – difficulty of the activity (Item 02), chemistry oriented activities.

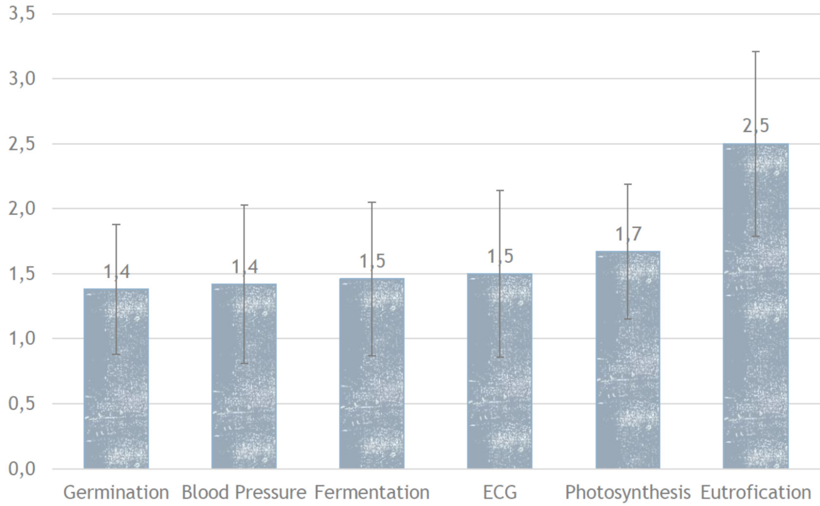

Figure 3. Mean values of teachers′ evaluation of selected activities – difficulty of the activity (Item 02), biology oriented activities.

Table 5. Comparison of the teachers′ evaluation of duration of the activity (Item 03) for the particular activities.

ACTIVITY	OPTIMAL	ADEQUATE	LONG	TOO LONG
CHEM 01	23%	69%	8%	0%
CHEM 02	60%	32%	8%	0%
CHEM 03	50%	33%	17%	0%
CHEM 04	15%	69%	15%	0%
CHEM 05	38%	38%	15%	8%
CHEM 06	23%	62%	15%	0%
CHEM 07	80%	20%	0%	0%
CHEM 12	0%	100%	0%	0%
BIO 01	58%	42%	0%	0%
BIO 02	33%	33%	33%	0%
BIO 03	0%	100%	0%	0%
BIO 04	62%	29%	10%	0%
BIO 05	67%	33%	0%	0%
BIO 06	47%	47%	0%	5%

The analysis of Item 04 shows that all the biology activities (BIO 01 – 06) and the chemistry activities CHEM 02, CHEM 05 and CHEM 07 well fit the state curriculum in both the countries. The other activities are still considered to fulfil the curriculum requirements, nevertheless, the evaluations of teachers are not so positive (see Table 6). In the case of activities CHEM 06 and CHEM 12 (Redox titration), high ratio of teachers (more than 30 %) considered that only a small part of these activities could be applied in classroom with respect to their curriculum.

Table 6. Comparison of the teachers′ evaluation of fit of the activity (Item 04) to the state (or school) educational curriculum for the particular activities.

ACTIVITY	VERY ADEQUATE	ADEQUATE	ONLY SMALL PART	NOT SUTABLE
CHEM 01	15%	69%	15%	0%
CHEM 02	63%	38%	0%	0%
CHEM 03	0%	83%	17%	0%
CHEM 04	8%	85%	8%	0%
CHEM 05	46%	54%	0%	0%
CHEM 06	8%	54%	38%	0%
CHEM 07	40%	60%	0%	0%
CHEM 12	34%	33%	33%	0%
BIO 01	58%	38%	4%	0%
BIO 02	60%	40%	0%	0%
BIO 03	50%	50%	0%	0%
BIO 04	57%	43%	0%	0%
BIO 05	58%	38%	4%	0%
BIO 06	58%	42%	0%	0%

ITEM 05: The objectives of the activity are well designed.

ITEM 06: Instructions for students are clear and have logical structure.

Majority of teachers participating in evaluation also stated that the objectives of the activities are well designed (average mark was 1.3 on 4-point scale, 99 % voted mark 1 or 2) and have clear and logical structure (1.5, 95 %). There is no statistically significant difference between Czech and Slovak teachers (Item 05: $U = 4\,949.500$; $z = 1.221$; $\boldsymbol{p = .222}$; $MR_{Czech} = 93.62$, $MR_{Slovak} = 102.24$; Item 06: $U = 4\,438.000$; $z = -.332$; $\boldsymbol{p = .740}$; $MR_{Czech} = 100.53$, $MR_{Slovak} = 98.08$), however, there is statistically significant difference among the activities (Item 05: $\chi2(4) = 40.798$; $\boldsymbol{p = .001}$; Item 05: $\chi2(4) = 38.895$; $\boldsymbol{p = .002}$). As very well designed, the activities CHEM 02 (Antacids), CHEM 07 (Wine titration), CHEM 03 (Greenhouse), CHEM 04 (Fire extinguisher), BIO 01 (Yeast fermentation), BIO 04 (Germination), BIO 05 (EKG) and BIO 06 (Blood pressure) can be considered, as majority of teachers (> 50 %) evaluated them by highest mark and no teachers attributed them bad design. On the tail of this ranking, the CHEM 06 (Cleaning liquid) and BIO 02 (Photosynthesis) can be placed as some small number of teachers (ca 5 %) reported bad design or they had high ratio of "just good" design (mark 2 on the 4-point scale; BIO 02 – more than 80 %). The activities with clear and logical structure, by opinion of participating teachers, are especially the activities CHEM 02, CHEM 05 (Acid rains), CHEM 07 and BIO 04 – BIO 06 as all of these activities were rated by highest mark by majority of teachers. In contrary, activities CHEM 01, CHEM 06, and BIO 02 (Photosynthesis) would deserve some refining with respect to the instructions provided to students, because more than 10 % of teachers evaluated them as not very clear (see Table 7). If we compare the clarity of the instructions reported by teachers and by students, we can find that both the groups evaluated the activities almost identically, with an average mark of 1.5 or 1.6, respectively.

Table 7. Comparison of the teachers' evaluation of clarity and logical structure of the instructions for students (Item 06) for the particular activities.

ACTIVITY	VERY CLEAR	CLEAR	NOT VERY CLEAR	CONFUSING
CHEM 01	23%	62%	15%	0%
CHEM 02	80%	20%	0%	0%
CHEM 03	50%	50%	0%	0%
CHEM 04	46%	54%	0%	0%
CHEM 05	62%	31%	8%	0%
CHEM 06	31%	54%	15%	0%
CHEM 07	80%	20%	0%	0%
CHEM 12	0%	100%	0%	0%
BIO 01	42%	50%	8%	0%
BIO 02	17%	50%	33%	0%
BIO 03	0%	100%	0%	0%
BIO 04	67%	33%	0%	0%
BIO 05	67%	29%	4%	0%
BIO 06	74%	26%	0%	0%

On the basis of the evaluation of the activities presented above, we can sort the activities into three groups. Simple activities with very appropriate duration time, well reproducible, and very suitable for beginners (in MBL and/or IBSE fields). The second group are the activities well evaluated, but little bit more difficult or taking longer. These activities can be still considered as suitable for regular class, nevertheless, an attention to good preparation and organization of the class must be taken into account, the participation of better experienced teacher and/or students in the course is also recommended. Finally, the third group of activities contains the activities with long duration and/or difficulty and/or more open IBSE activities. Hence, the activities of this pool can be recommended only to experienced teachers or, especially, for talented students or students with interest in science as higher autonomy of student is necessary. The distribution of the activities into the groups is summarized in Table 8.

Table 8. Distribution of the particular activities into groups on the basis of their implementation potential.

No. of group	Description of the group	Activities
1	Simple activities with very appropriate duration time, well reproducible, and very suitable for beginners (in MBL and/or IBSE fields)	CHEM 02, CHEM 05, CHEM 07, BIO 04, BIO 05, BIO 06
2	Activities well evaluated, but little bit more difficult or taking longer. Attention to good preparation and organization of the class must be taken into account.	CHEM 03, CHEM 04, CHEM 06, CHEM 12
3	Long duration and/or difficulty and/or more open IBSE activities. They can be recommended only to experienced teachers or, especially, for talented students or students with interest in science as higher autonomy of student is necessary.	CHEM 01, BIO 02, BIO 03

Issues in working with MBL system

ITEM 07: It was easy for students to work with the computer system.

ITEM 08: Students needed teacher's help to comprehend the principle and the objectives of this activity.

ITEM 09: Students needed teacher's help to design and perform the experiments in this activity.

Majority of teachers (97 %) participating in the evaluation indicated that it was easy for students to work with the MBL system. There was no statistically significant difference between Czech and Slovak teachers ($U = 4\,627.500$; $z = .601$;

***p* = .548**; MR_{Czech} = 95.23, MR_{Slovak} = 99.62). Interestingly, teachers′ evaluation well corresponded with students′ evaluations, as both the groups rated simplicity of work with MBL system with the same average mark of 1.6. The results indicate that school MBL systems can be really considered as well designed systems for school use and the fears of teachers as well as students, if system works well, will not be drawback in implementation of MBL into schools.

Despite the positive evaluation of work with MBL system by students as well as teachers, the Items 08 and 09 revealed still high amount of help provided by teachers to the students. In both of the items, the Czech teachers report similar portion of help provided by teachers as Slovak teachers (Item 08: U = 4 855.000; z = 1.252; ***p* = .210**; MR_{Czech} = 92.07, MR_{Slovak} = 101.47; U = 4 444.000; z = .050; ***p* = .960**; MR_{Czech} = 97.78, MR_{Slovak} = 98.13). In overall, teachers reported amount of help provided to students as 99 %, which indicates, that in any performed activity, some help provided by teacher is required. The results also show that about 20 % of help is a principal and important help (continuous help necessary to finish the objectives of the activity – mark 1 at the 4-point scale), 60 % are attributed to occasional help with some particular issues, small amount of help (once or twice per course) is about 18 % and only 2 % of teachers reported that no help was necessary during the MBL course. The comments in the questionnaire and experience of researches from the courses indicate that majority of the amount of help (ca 55 %) can be attributed to usage of MBL system (set-up of the system, technical problems, software and hardware issues, questions related to control of the system, …), and the smaller portion only to other problems (preparation of solutions, how to use a burette, theoretical problems, …). Although the help provided to students by teachers is mostly occasional, the total amount of help and also a portion attributed to work with MBL system are relatively high. Comparing to the “regular” laboratory course without MBL, the course with MBL seems to be ca 2 times more demanding for teachers. It can be considered to be a problem in implementation of MBL into secondary schools and should be taken into account when organizing MBL course. The result also indicates, that problems connected to MBL approach are rather frequent and teachers must be well prepared and experienced to conduct a MBL course, which also rationalize organization of appropriate courses for pre-service teachers in the framework of their university curriculum as well as for in-service teachers in the framework of their professional development. If we compare the results of analysis of answers to Item 09 provided by teachers with results provided by students, in the case of the Czech Republic, the patterns of the answers are very similar and also well comparable to answers of Slovak teachers. In particular, ca 20 % of both of the group reported principal help, ca 50 % occasional help and 20 % rare help. No provided help was reported by roughly 10 % of students as well as teachers (see Chart 3). In contrast, the reports of Slovak teachers and students are different (see Chart 4). It seems that Slovak students underestimated the amount of help provided by teachers, probably due to their higher motivation (Smejkal et al. 2017), as there is no reason for different portions of help in the individual categories. Despite that, Slovak students still report high portion of help needed which, again, stress attention to good preparation and organization of the MBL courses.

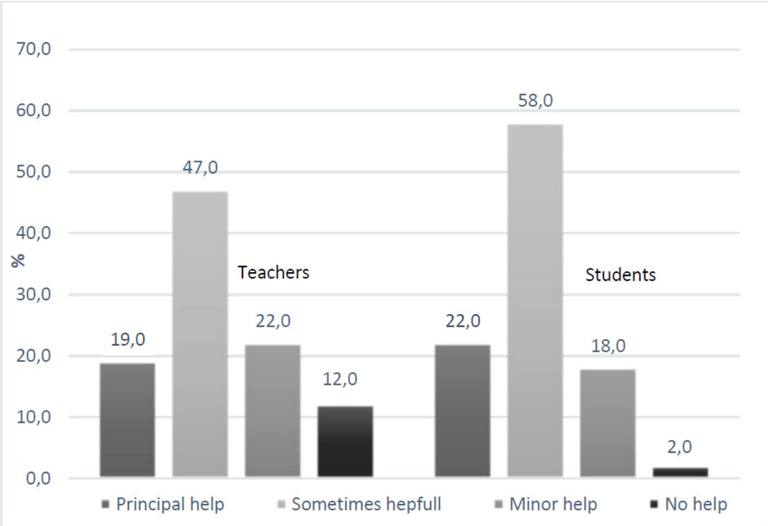

Figure 4. Comparison of "amount" of help provided by teachers to students during MBL laboratory course reported by **Czech** *teachers (left) and students (right).*

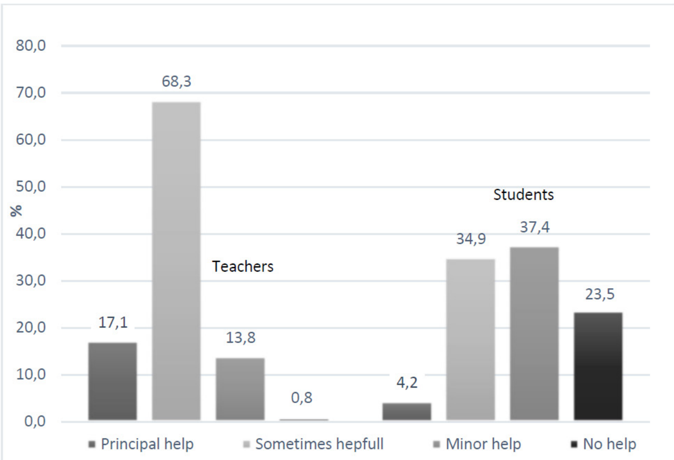

Figure 5. Comparison of "amount" of help provided by teachers to students during MBL laboratory course reported by **Czech** *teachers (left) and students (right).*

The result is further supported by analysis of the last selected item in the questionnaire, which evaluated comments of teachers on “Most stressed parts to work with MBL system”. Although only few teachers commented this Item, the analysis showed that “fears” of teachers are mostly oriented to technical aspects and issues (how to use the MBL system?, problems with hardware and/or software, what to do if … - 46 %) and to methodology and organization aspects (30 %). Also, the lack of appropriate worksheets and materials which can be employed in MBL courses can be a source of “fears” of teachers implementing MBL courses and, hence, an existence of well prepared and tested and evaluated worksheets would be appreciated (ca 23 %). These results rationalize again organization of appropriate courses on MBL for pre-service teachers in the framework of their university curriculum as well as for in-service teachers in the framework of their professional development and also preparation of new activities which employ the MBL systems.

Conclusions

A new research-based framework for computer based laboratory activities in science education has been proposed and implemented. The activities were evaluated by teachers very positively and in the case of majority of activities, teachers considered their duration, difficulty and content (with respect to the state and school curriculum) as optimal. The teachers also considered the objectives to be defined adequately and instructions as clear.

In all the analysed items of the questionnaire, there was no difference between the Czech and Slovak teachers, probably due to their similar conditions of their professional preparation as majority of them started their professional career (or life) in former Czechoslovakia or soon after the splitting of the country. Although, there was no difference between the Czech and Slovak teachers, there was difference between Czech teachers and students as teachers evaluated the activities more positively than students, probably due to longer experience with MBL systems. On the other hand, all the students as well as teachers of both of the countries rated the instructions of the activities very similarly as clear with a logical structure.

The analysis showed significant differences among the particular activities. On the basis of the analysis, the activities were sorted into three groups with respect to a purpose of application and/or implementation potential: *a)* Simple activities with very appropriate duration time, well reproducible, and very suitable for beginners (in MBL and/or IBSE fields). *b)* Activities well evaluated, but little bit more difficult or taking longer. These activities can be still considered as suitable for regular class, nevertheless, an attention to good preparation and organization of the class must be taken into account, the participation of better experienced teacher and/or students in the course is also recommended. *c)* Activities with longer duration and/or difficulty and/or more open IBSE character. Hence, the activities of this pool can be recommended only to experienced teachers or, especially, for talented students or students with interest in science as higher autonomy of student is necessary.

Despite very positive evaluation of the activities as well as of set-up and work with MBL systems by teachers as well as students, the course with MBL can be still considered more demanding for teachers than "regular" courses held without the MBL systems. The issues and obstacles connected to usage of MBL systems and which require teacher´s attention and help provided to students, give still relatively high portion of all the help provided to students (ca more than 50 %). This drawback in implementation should be compensated by appropriate teacher´s preparation before MBL course and also rationalize existence of appropriate courses for pre-service teachers in the framework of their university curriculum as well as for in-service teachers in the framework of their professional development.

The analysis of teachers´ opinions related to the "fears" of teachers implementing MBL courses, and, hence, the most appreciated parts of MBL course for teachers, revealed that these "fears" are mostly oriented to technical aspects and issues, methodology and organization aspects and lack of availability of tested and evaluated worksheets. These results rationalize again organization of appropriate courses on MBL for pre-service teachers in the framework of their university curriculum as well as for in-service teachers in the framework of their professional development and also preparation of new activities and materials (worksheets, tutorials) which employ the MBL systems.

Acknowledgment

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Comprehending Computer Based Laboratory Activities by Slovak and Czech Students

Background

In present, computer supported experimenting is believed to be a beneficial part of science education. Some authors tend to believe that it supports a constructivist view of education and allows using higher order learning skills (Aksela, 2005) and supports a better teacher implementation (Lavonen et al. 2003). In this context, one of the roles of researchers working in the field is to design new activities and experimental tasks for computer based laboratories (formerly Microcomputer-based Laboratory, MBL, Thornton 1990). Working in such laboratories, sometimes called real-time experimenting, allows students to figure out many features of science competencies, having a quick and continuous interaction with new learning they acquire (Tortosa et al., 2013).

Rationale

The framework for this study is a set of newly designed research-based computer aided laboratory activities for Chemistry and Biology proposed in the last 4 years by the international team consisted of researchers from 5 European countries: Spain, Czech Republic, Austria, Finland and Slovakia (Tortosa et al., 2014; Tortosa et al., 2013). Herein, we present the partial outcomes resulting from Czech and Slovak part of the research focusing on four main areas inspected after implementing the proposed laboratory activities:

1. Do students understand the objectives of the activities?
2. Do students need their teacher's help to understand the activities?
3. Do students feel that working with measuring system can help them learning?
4. Do students recognize the importance of measuring system in such experimenting?

Especially, first two areas are very important to reveal because it is believed and confirmed by the studies (Lijnse, 2004) that if students see the point of what they are doing, the processes of teaching and learning probably make more sense to them and can be more efficient.

Methods

In this study 18 newly designed computer aided laboratory activities (Table 1), 12 for Chemistry and 6 for Biology, were designed and tested with secondary school students in Slovakia and Czech Republic.

Table 1. The list of implemented activities (CHEM = Chemistry, BIO = Biology).

	Activity
CHEM 01	CO_2 in the Sea. *(pH measurement)*
CHEM 02	Antacids and the stomach acid *(Acids and bases, neutralization)*
CHEM 03	The Greenhouse problem *(Spectrophotometry)*
CHEM 04	Fire extinguisher *(Gas production, gas pressure)*
CHEM 05	Acid Rains *(Acids and bases, neutralization)*
CHEM 06	Cleaning Liquid *(Acids and bases, neutralization)*
CHEM 07	Red or white? Sweet or dry? *(Acidity of wine)*
CHEM 08	Quality of water: How to determine chloride content in a tap water?
CHEM 09	What dye is present in the drink? *(Spectrophotometry)*
CHEM 10	What is the content of the dye in the drink? *(Spectrophotometry)*
CHEM 11	Gas chromatography
CHEM 12	Redox titration: How to determine hydrogen peroxide
BIO 01	The life of Yeast. *(Fermentation)*
BIO 02	Photosynthesis
BIO 03	Eutrophication
BIO 04	What are the best conditions for seeds to germinate? *(Seed Germination)*
BIO 05	What makes your heart stand still? *(EKG)*
BIO 06	Blood Pressure, do you know what it is? *(Blood Pressure)*

The uniform structure of the activities was prepared collaboratively by all participating international partners and can be seen in Figure 1. The background for the structure was inspired by the previous research-based frameworks suggested by Pintó et al. (2010), Espinoza & Quarless (2010) and Tortosa (2012). All activities are designed to be student-centered reflecting the IBSE principles. Some parts of them also follow the well-known POE sequence (Predict – Observe – Explain) suggested by White & Gunstone (1992).

As during the testing, each student usually implemented more than one activity, 1408 evaluations (932 in Czech Republic and 476 in Slovakia) were performed in total with 664 students (518 in Czech Republic, 146 in Slovakia) attending 15 participating schools (11 in Czech Republic, 4 in Slovakia). The students mean age was 16.97 (SD = 1.20). Due to serious lack of necessary equipment in the majority of participating schools the most of the implementations (919) were realized in the university laboratories (Charles University in Prague, Czech Republic and Matej Bel University in Banská Bystrica, Slovakia). More specifically, in Czech Republic 489 implementations were performed at current schools with their current teachers who had been trained for the implementations before. On the other hand, all implementations in Slovakia were performed at university. 628 implementations (210 in Slovakia and 418 in Czech Republic) were performed with activities for Chemistry and 780 implementations (266 in Slovakia and 514 in Czech Republic) with activities for Biology.

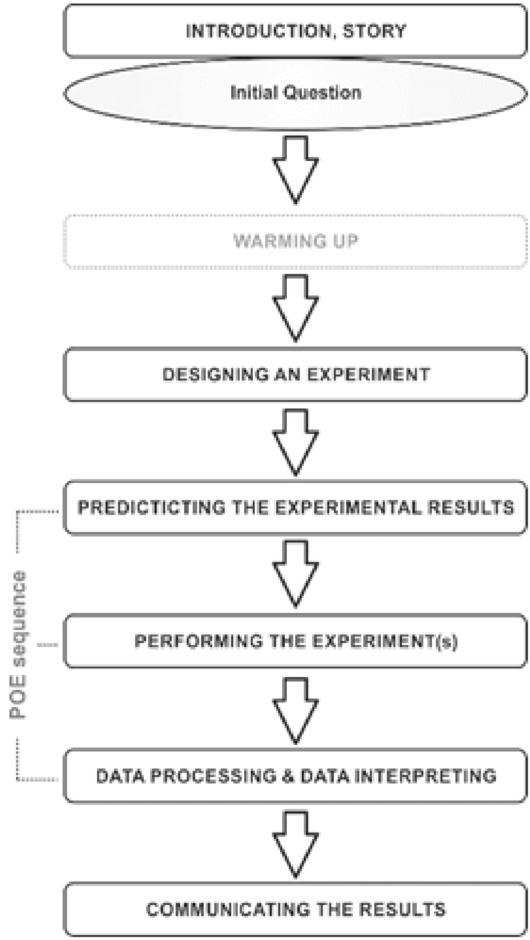

Figure 1. The uniform structure of the designed activities (The POE sequence is also depicted).

In order to gain a relevant feedback about the quality of tested activities a special tool (a 20-item questionnaire) has been administered to the respondents after performing each activity (implementation). For this study five following questionnaire items were selected to discuss in more detail considering 4 research areas listed above:

Item 01: I understood the objectives of the activity.

Item 02: List the objectives of the activity.

Item 03: I need my teacher’s help to understand the activity.

Item 04: Computer measuring system helped me interpret the results (e.g. graphs).

Item 05: I think the activity could be done without computer measuring system.

As obvious, items number 1, 3, 4 and 5 are positive declarative clauses where students were asked to express their level of agreement on 4-point Likert scale (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree). Item number 2 is an open item where the accuracy of the responses was evaluated on the 4-point scale as follows: 1 = correct answer, 2 = more or less correct answer, 3 = not sufficient answer, 4 = totally erroneous answer.

A variety of statistical methods have been used to process collected data, e.g. descriptive statistics, analysis of frequencies and comparative analysis (gender, subject, country, age, place of implementation) where the significance was determined by non-parametric tests (Mann-Whitney U test or Kruskal-Wallis H test) at 0.05 level.

Results

ITEM 01: I understand the objectives of the activity
ITEM 02: List the objectives of the activity

According to the outputs from analysis of frequencies shown in Table 2 the most of the students (94.7%) think that they understand the objectives of the implemented activity (cumulative percent for all answers of agreement with the declarative statement has been taken into account). However, when they were asked to list the objectives the results were not so positive. It can be seen in Table 3 that respondents provided only 58.1% of correct (scale point 1) or more or less correct (scale point 2) answers. Therefore, it is obvious that students tend to overrate their ability of understanding. Nevertheless, the fact is that there really were some problems in comprehending the point of the implemented activities and it was needed to identify the most frequent obstacles.

Table 2. Frequencies and percentages to the item I understood the objectives of the activity. (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree).

		Frequency	Percent	Valid percent	Cumulative percent
Valid	**1**	795	56.5	58.0	58.0
	2	504	35.8	36.8	94.7
	3	56	4.0	4.1	98.8
	4	16	1.1	1.2	100.0
	Total	1371	97.4	100.0	
Missing	**0**	37	2.6		
Total		1408	100.0		

Table 3. Frequencies and percentages to the item List the objectives of the activity. (1 = correct answer, 2 = more or less correct answer, 3 – not sufficient answer, 4 = totally erroneous answer).

		Frequency	Percent	Valid percent	Cumulative percent
Valid	**1**	320	22.7	25.1	25.1
	2	422	30.0	33.0	58.1
	3	395	28.1	30.9	89.0
	4	140	9.9	11.0	100.0
	Total	1277	90.7	100.0	
Missing	**0**	131	9.3		
Total		1408	100.0		

Apparently, the results mentioned above don't distinguish between the activities. This is why it was also important to compare them and to uncover the most difficult ones for students to comprehend. Figures 2 and 3 show the differences in how students think they understand the objectives of the activities and how they really do in separate subjects. The results indicate that the most questionable activities are CHEM 06, CHEM 08, BIO 02 and BIO 04. These activities needed the most precise revisions.

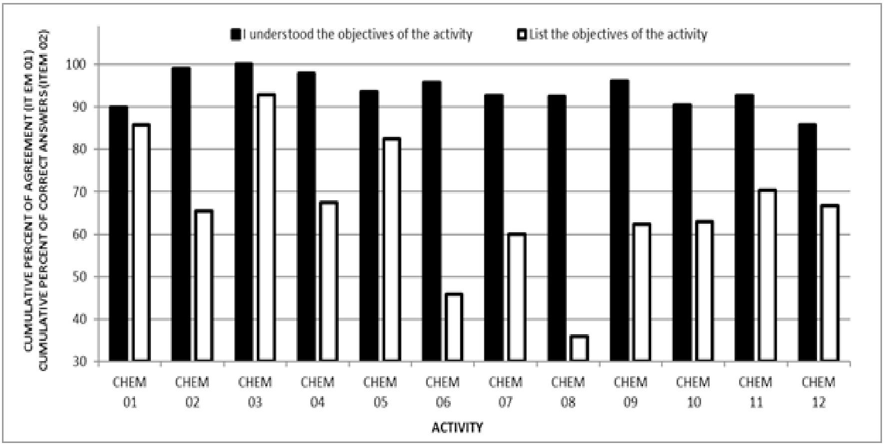

Figure 2. Understanding the objectives of activities for Chemistry.

It was less important but also interesting to perform the comparative analysis considering several factors of potential difference: (i) gender, (ii) place of implementation, (iii) country, (iv) subject and (v) age. When compared between males and females by means of Mann-Whitney U test, no significant difference was found in how they think they understand the objectives of the activities. On the other hand, significant differences appeared after listing the objectives (U =

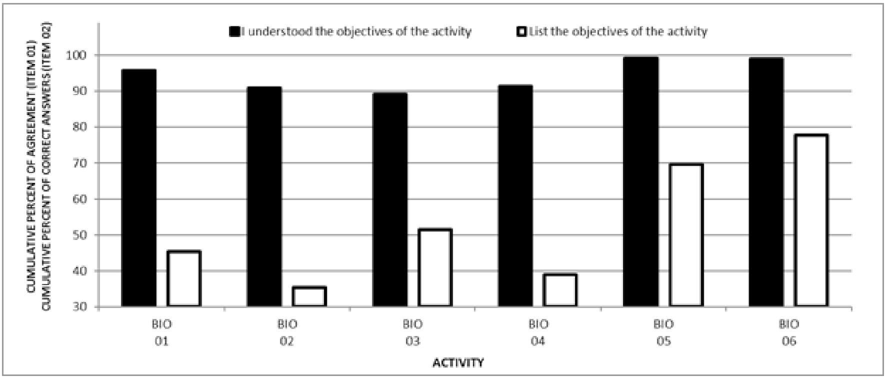

Figure 3 Understanding the objectives of activities for Biology.

181 287.500; $z = -2.955$; $\boldsymbol{p = .003}$), where male students provided correct answers more frequently (Mean Rank (MR) = 613.68) than their female schoolmates (Mean Rank = 672.68).

Interestingly, statistically significant differences regarding both first two items were also found when compared different places of implementation. The outputs from Mann-Whitney U test favour working in university compared to working in the schools (ITEM 01: $U = 251\ 102.000$; $z = 6.356$; $\boldsymbol{p = .000}$; $MR_{school} = 757.25$, $MR_{university} = 643.06$; ITEM 02: $U = 251\ 102.000$; $z = 6.356$; $\boldsymbol{p = .000}$; $MR_{school} = 726.75$, $MR_{university} = 596.35$). It seems that students performing in university not only felt more competent but also reported more correct answers than students working in the schools. Farther comparisons showed that some of the other factors can also generate statistically significant differences between the considered groups. Comparison between countries showed that Slovak students tend to report more positive answers in ITEM 01 ($U = 169\ 110.500$; $z = -7.238$; $\boldsymbol{p = .}000$; $MR_{SK} = 593.77$; $MR_{CZ} = 735.05$) and also provided more correct answers in ITEM 02 ($U = 153\ 669.500$; $z = -5.317$; $\boldsymbol{p = .000}$; $MR_{SK} = 567.51$; $MR_{CZ} = 677.63$). Subject (Chemistry and Biology) generated statistically significant difference only in listing the objectives where Chemistry produced more frequent correct answers than Biology ($U = 216\ 174.500$; $z = 2.265$; $\boldsymbol{p = .024}$; $MR_{Chemistry} = 614.35$; $MR_{Biology} = 659.32$). Finally, Kruskal-Wallis H test revealed no significant difference generated by respondets' age.

ITEM 03: I need my teacher's help to understand the activity

In Table 4 it can be seen that about 45% of the students declared the need of their teacher's help in understanding the objectives of the activity (again, cumulative percent for all answers of agreement with the declarative statement has been taken into account). On the other hand, we can say that almost 55% of them did not need help like this. One way or another, it is necessary to know what activities require the most acute teacher's help. Data comparison between the activities (Figure 4) revealed that the most frequent request for the teacher's help was reported in activities CHEM 10 and BIO 03.

Furthermore, comparative analysis showed that no significant difference between compared groups is generated by gender and subject. On the other hand, students performing in university reported significantly less frequent need of their teacher's help then students implementing in the schools (U = 178 029.000; z = –5.486; $\boldsymbol{p = .000}$; MR_{School} = 612.51; $MR_{University}$ = 730.13). The difference between countries was also statistically significant, where Czech students asked for the teacher's help more frequently then Slovak respondents (U = 269 984.500; z = 8.279; $\boldsymbol{p = .000}$; MR_{SK} = 805.69; MR_{CZ} = 628.1). Kruskal-Wallis H test revealed no significant difference generated by age of respondents.

Table 4. Frequencies and percentages to the item I need my teacher's help to understand the activity. (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree).

		Frequency	Percent	Valid percent	Cumulative percent
Valid	**1**	139	9.9	10.1	10.1
	2	487	34.6	35.3	45.4
	3	482	34.2	35.0	80.4
	4	270	19.2	19.6	100.0
	Total	1378	97.9	100.0	
Missing	**0**	29	2.1		
	System	1	.1		
	Total	30	2.1		
Total		1408	100.0		

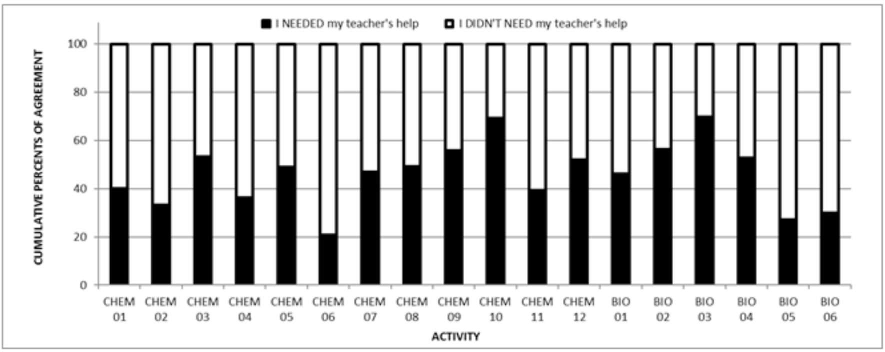

Figure 4. The need of teacher's help in understanding the objectives of the activity. Comparison between the activities.

ITEM 04: Computer measuring system helped me interpret the results (e.g. graphs).

In ITEM 04 the most students reported that computer measuring system helped them in interpreting the results (Table 5). When compared the relevant groups, the results were similar to the previous item (ITEM 03). We found significant differences generated by place of implementation and country. Students working in university laboratories considered computer measuring system helpful more often than students working in the schools (U = 250 486.000; z = 5.916; $\boldsymbol{p}$ **= .000;** MR_{School} = 765,95; $MR_{University}$ = 647,80). Analogously, Slovak students provided similar responses when compared to Czech students (U = 282 292.500; z = –7.314; $\boldsymbol{p}$ **= .000;** MR_{SK} = 593.05; MR_{CZ} = 738.98). Again, no significant difference regarding age was recorded by Kruskal-Wallis H test.

Table 5. Frequencies and percentages to the item Computer measuring system helped me interpret the results (e.g. graphs). (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree).

		Frequency	Percent	Valid percent	Cumulative percent
Valid	**1**	718	51.0	52.2	52.2
	2	575	40.8	41.8	94.0
	3	66	4.7	4.8	98.8
	4	17	1.2	1.2	100.0
	Total	1376	97.7	100.0	
Missing	**0**	31	2.2		
	System	1	.1		
	Total	32	2.3		
Total		1408	100.0		

ITEM 05: I think the activity could be done without computer measuring system.

In ITEM 05 we asked students if they think the activity they are just performing could be also realized without computer measuring system. In general, more than one third of them (35.4%) reported positive answers (Table 6). A comparison between the activities (Figure 5) uncovered that students tend to consider the measuring system not necessary in activities CHEM 03 and BIO 06. Mann-Whitney U test and Kruskal-Wallis H test for other comparisons (considering all already mentioned factors) did not show statistically significant differences between relevant groups.

Table 6. Frequencies and percentages to the item I think the activity could be done without computer measuring system. (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree).

		Frequency	Percent	Valid percent	Cumulative percent
Valid	**1**	118	8.4	9.0	9.0
	2	348	24.7	26.4	35.4
	3	550	39.1	41.8	77.1
	4	301	21.4	22.9	100.0
	Total	1317	93.5	100.0	
Missing	**0**	89	6.3		
	System	2	.1		
	Total	91	6.5		
Total		1408	100.0		

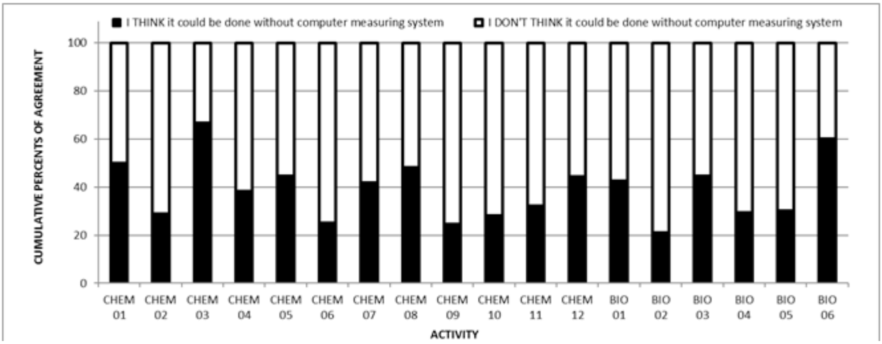

Figure 5. The necessity of computer measuring system in performing the activities. Comparison between the activities.

Conclusions

A new research-based framework for computer based laboratory activities in science education has been proposed and implemented. In accordance with our previous studies (Tortosa et al., 2013; Skoršepa, 2015), the actual study also uncovered that most students tend to perceive their level of understanding the activity more overrated then reality. This fact is one of the important fragments being able to help us in refining the activities. Furthermore, the study also showed an interesting indication of place of implementation impact on student's level of engagement. It seems that students working in university probably felt more competent to figure out the activities then students implementing in the schools. They also reported less need of their teachers help in understanding the activities when working in the university labs. Accordingly, the level of help of computer measuring system in interpreting the results was declared more notably by the students working in university. We are not sure about the reasons of such findings but we can presume that new, not-known and serious environment like university and its laboratory can also influence students in their behaviour and make them more engaged and active for learning.

It is very promising that almost all students considered computer measuring system helpful in figuring out the experimental problem that they were working on.

A bit surprising fact was that about one third of responses haven't recognized the importance of computer measuring system support in the activities. In some activities students thought they could be performed without computer measuring system. We suppose that such opinions could be influenced by not sufficient experience of our students with work in computer based laboratories. Namely, it was the first experience with computer measuring system for the most of our respondents. In conclusion, our findings suggest that tested research-based laboratory materials could be useful and of quality for the most of the students. However further research is needed to comprehend all relations recorded by this study.

Acknowledgements

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Transmedia in Natural Sciences Education

Introduction: The role of education in information society

In the modern world, it is the media which constitutes the communication environment of the society – it is the media which prioratises and imposes the significance of news presented in information programmes, explains 'how things are in the world' and creates politicians and artists. It is the media which shapes esthetic tastes and imposes issues we should engage in to develop ourselves. It is the media which 'educates' telling us which newspapers and books to read, which films to watch and music to listen to, where to travel, which places to visit, what to eat and how to dress; in a nutshell, the media tells us how to live worthwhile lives (Pietrzak 2015).

As A. Dróżdż (2000) acknowledges, "people accept that group subconsciousness is controlled by social network engineers and free market managers. Being heavily conditioned by culture we are much less aware of our choices than we could assume (Warecki, 2007). Information overload leads to passive observation where possessing information replaces acting (Baranm, Davis 2009). Therefore, we succumb to the media manipulation so willingly, as it relieves us of making decisions and taking responsibility.

The transformation of industrial society into knowledge based society entails a need to adjust the content of education and acquired skills in order to prepare young people to function and work in a changing environment (Skrzydło, 2009). This means equipping them in universal civilisation competences such as: information verification, open-mindedness, ability to cooperate, creativity, responsibility and strength. In educational programmes solving dilemmas how to combine: *knowledge - comprehension, knowledge - how to act, knowledge - whom to be/what to be like* still remains the basic problem (A Framework...2005).

Specialists in different disciplines call for common sense media education, relying on universal values, applying technologies as tools to support teachers and school transformation into an institution that teaches problem-solving (Goban-Klas, 1999; Morbitzer, 2010, 2012). In the view of J. Bednarek (2006, s.28), education system should educate people to cooperate in teams as well as to prepare people not only to apply the knowledge acquired during repeated activities but to create it - a challenge education faces is conforming to knowledge variability and growth.

A proposal for well-thought education with the use of media is transmedia education i.e. arriving at knowledge by engaging learners/students by a teacher in the exploration of a scientific film (multiformat story) as well as co-creation of educational content with the use of field observations, lab experiments and discussions. The aim of such an approach to education is sharing the acquired knowledge with others using for this purpose social media (Pietrzak, 2013, s.312).

The article shows how a teacher of geography, introducing learners/students to the world of transmedia film, engages them in searching, collecting information about geographical environment (in various formats – film, sound graphic and text files), making scientific observations and open-mindedness in communication for the benefit of team activities.

Transmedia- origin and examples of application in education

Transmedia learning is adapted from commercial and entertainment industries. The idea of transmedia was first introduced in 1976 to support George Lucas's Star Wars and later Indiana Jones (Jenkins, 2003). Publishing groups were formed to produce and promote products associated with the films: toys, books, cartoons, computer games, films, websites and fun clubs. According to Henry Jenkins "In transmedia storytelling each medium does what it does best so that a story might be introduced at the film, expanded through television, novels and comics; its world might be explored through game play or experienced as an amusement park attraction. A transmedia story unfolds across the multiple media platforms, with each new text making a distinctive and valuable contribution to the whole"" (Jenkins, 2006). Nowadays, the design of transmedia storytelling is widely used in entertainment advertising and commercial games industries. E. Raybourn presents definitions of transmedia in business context and formulates them with reference to education (Raybourn, 2007). The Author defines transmedia storytelling as: "the system of messages that reveal a narrative or engender an experience through multiple media platforms, emotionally connecting with learners by involving them personally", whereas transmedia learning as "the sustained experience that results in measurable behavior change. The behavior can be physical and overt, intellectual, attitudinal, or a combination of all" (Rebourn, 2007) In the article the Author quotes examples of educating American Army soldiers in the form of strategic communication and serious game training (Reybourn, 2014). She demonstrates how to apply in transmedia leaning such elements as: Internet, serious games, video, social media, graphic novels, machinima, blogs, and alternate reality gaming.

An example of applying films in history education is a proposal of creating a video by students to compose a documentary using historical artifacts, document landmarks in their neighborhoods or communities or they can interview people in their communities about their memories of historical events (Hammond and Lee, 2009). As the authors emphasise, "students can watch digital video that makes distant times or places more accessible, develop their research and primary source analysis skills, and even come to understand the interpretive nature of historical accounts" (Hammond and Lee, 2009).

Valuable examples of applying multimedia in education of both very young learners and adults, including those with disfunctions (people with Autism, blind or having severe visual impairment) are described in an article by Malik and Agarwal (2012). The Authors emphasise that it encourages and enhances peer learning as well as individual creativity and innovation.

A particularly interesting example is a fusion of new media with the animation therapy (Kino-Ani-Drama Therapy including Dance and Drama Therapy, Music Therapy & Painting Therapy) in order to reduce teenagers' problems and help them control their stress and anxiety caused by the compulsive use of media by constructively engaging them in media production (Park et al., 2009).

A review of literature on applying films from YouTube and advantages as well as disadvantages of this medium in education have been characterized in an article by Jones and Cuthrell (2011). The Authors reflected on the fact that "YouTube can be used as a tool to inform and display and as a forum for critical analysis and commentary". At the same time, they indicate a drawback of YouTube which is a hazard that a video may be deleted or removed.

A publication *Multimedia in Education,* published by UNECSCO, widely describes lesson plans with the use of multimedia. In a chapter devoted to the production of multimedia materials, designing multimedia is acknowledged as a complex process, which demands high-order skills and strategies from the learner, such as: planning, research skills, organization skills, presentation skills and reflection skills (Andersen and Brink, 2013).

What differentiates examples characterized in the abovementioned literature and education approach presented in this article is transmedia film designed specifically for the course. In the proposals there are no transmedia films made by the teacher for educational purposes, specially dedicated to a particular teaching area. This article contains both a description of transmedia storytelling (interchangeably applied terms for film are transmedia movie and transmedia narrative film), as well as a technique of involving students in broadening film content i.e. transmedia learning.

An answer to a question whether it is justified to apply new technologies in educating Polish pupils/students can be found in the characteristics of the population of digital natives. According to GUS surveys, computers are used by approximately 10% three-year-olds, half of five-year-olds and as many as 82% seven-year old children. Among children attending primary and middle school, 95% have PCs and 90% - access to the Internet. In 2014, among 12-15-year-old teenagers, 95.4% regularly used the Internet. The most common reason for using the Internet was using social networking sites – 77.2% young people connected with the net for that reason, 64.5% to use e-mail, 64% to play or download computer games, listen to or download music and download films, 59.2% accounted for persons searching the Internet for information needed for their learning.

The results of research conducted by G. Small and N. Carr, mentioned in J. Morbitzer's article, indicate that "young Internet users, having access to bigger and bigger amount of information, understand and know less and less, their knowledge becomes sketchy and shallow, missing brilliance and knowledge of a wider context" (Morbitzer, 2012, p.5). Therefore, education systems worldwide must support the teaching digital natives of New Media Literacies.

New Media Consortium includes media literacies to skills essential in 21 century, defining them as follows: "21st century literacy is the set of abilities and skills where aural, visual and digital literacy overlap. These include the ability to understand the power of images and sounds, to recognize and use that power, to manipulate and transform digital media, to distribute them pervasively, and to easily adapt them to new forms" (A Global Imperative 2005).

A wide review of opinions on features of the, so called, Digital Natives (or Net Generation, Gamer Generation, Google Generation, Instant Message Generation) is included in Chris and Shao's publication (2011). On the basis of the subject literature the authors conclude that today's generation of young people think, learn and behave differently to former generations. As an example: "The new generation of students are said to prefer receiving information quickly, relying on communication technologies, often multitasking and having a low tolerance for lectures, preferring active rather than passive learning" (Chris and Shao, 2011). At the same time, the Authors point out that this statement cannot be extended to the whole generation of young people since they do not form a homogeneous generational group. They significantly differ from one another. However, the ubiquity of digital technology as well as a need for constant communication in today's labour market require preparation of young people to make effective use of multimedia. A question remains whether transmedia education ensures such training. Probably not, as it is only one way of educating. However, given the fact that on both sides of the learning process – teacher-student- there are persons with diversified skills and interests, this constitutes an education proposal suitable for the times.

Transmedia in natural sciences education

Effective natural sciences education requires the following: transferring knowledge in a holistic way, adjusted to the needs of the information society (with the use of Internet information resources), direct contact with nature (the environment), multisensory exploration of natural phenomena, selecting information, formulating personal evaluations and understanding opinions of other people.

First of all students were assumed to search for answers to questions concerning geographical space, and to be precise, to answer questions which deal with cause and effect relationships about the occurrence of forms, phenomena as well as natural and social processes in various places on the Earth. When future teachers of geography or other natural sciences subjects analyse special relations and connections between them, they should formulate such questions as: What is a given phenomenon/form or process? Why does it occur in this place/region on the Earth? Is it present in another place/region on the Earth? What is the scope of the phenomenon/form or process? What is its size? Is it unique or common? Does it occur ephemerally or it is rather long-lasting? What is its duration/ time of occurrence? Naturally, also other questions are possible. However, all should have answers which would present the characteristics of location and mutual relation between objects in different places or regions in the world. And all of that should be perceived through time function.

The reasons explaining contemporary state or condition of phenomena/forms/ or processes originate from both the past, considered at geological, archeological, historical or human life scale, as well as the present. They indicate directions of transformations and lead to forecasting and creating a concept of development in future. There are numerous questions and problems, hence a need for referring to different resources.

At this point, on-line resources of information come with help e.g. repositories of historical maps and photos, digital libraries and archives, statistical data collections, scientific institutions websites etc. The problem which still remains is the multitude of information and a question how to change students' attitudes, that is, their transformation from passive recipients to active explorers of knowledge. Holistic perception of any phenomena, and the use of various sources of information are a starting point for implementing transmedia in science education.

In order to prepare students for integrated nature science teaching at the secondary level, I developed a course on Transmedia in Science Education that combines field practice, laboratory experiments, creative techniques and ICT techniques in a student-created film narrative.

Starting from 2014/2015, the Institute of Geography and Spatial Management of the Jagiellonian University, launched a course which coherently combined the above mentioned activities. The 60-hour course 'Transmedia in Science Education' was made available for students of geography and Erasmus programme students.

Basic terms and structure of transmedia education

Transmedia education is a gradual acquiring of the knowledge through the teacher-guided involvement of students–researchers in the exploration of scientific multi-platform, multi-tier storytelling and ICT- aided participatory creation of educational content to be shared on social networking services (Pietrzak, 2013).

In the definition, transmedia education is treated as a teaching strategy. In view of its inspirational influence on students' engagement, it can be classified as one of the ways to shape attitudes.

Transmedia in education is an organised, and systematised, way of using media devices enabling to acquire knowledge and explore educational content, its co-creation and sharing. The above definition classifies transmedia as a didactic means, allowing to develop skills.

Transmedia educational story/storytelling – a film (picture) along with a text as a narration e.g. a description of an event, an explanation of a process or a given phenomenon, a presentation of a specific object. The film (picture) has its entry points, so called 'rabbit holes', which enable a student a precise exploration of the main topic, minor motifs and co-creation of the narration (a student gains knowledge).

Transmedia narrator is a teacher – a guide. A crecipient (a portmanteau word of creator and recipient) is a student - an explorer (in the world of media such persons were called a prosumer = producer and consumer).

Transmedia learning in natural sciences education requires making **5 steps, TVTEC,** which are characterized below. The acronym TVTEC stands for: 1. **T**ransmedia storytelling movie 2. **V**irtual educational cloud 3. **T**rip – field work 4. **E**xperiments 5. **C**ollaboration in the movie making project

1. The transmedia movie

The *Transmedia in Science Education* course begins with watching the movie "Exploring Krakow with Teme" (lasting 19'28"). The film tells the story of Krakow from different perspectives, i.e. from the perspective of the geological past of the city's area, from the perspective of the condition and changes in the geographical environment, as well as from the perspective of changes to urban planning, and those caused by the economic, political or cultural history of the city. The content, i.e. the text of the script, is based on scientific literature, and its scope is adapted to the curriculum of the course in geography.

The narrator of the story, and also the main protagonist and participant in its events, is an animated puppet representing the Wawel Dragon, a fairy-tale character and a symbol of Krakow. It was important that the movie featured a certain plot and drama, and was not just a cold presentation of facts as people more easily remember stories and emotions than facts, figures or dates.

The film was shot in a number of districts in Krakow. Shots of historical buildings, monuments, the city's infrastructure, rocks, caves, rivers, reservoirs, soils, parks, meadows, and large shots of Krakow's panorama were taken from different vantage points. Permission to shoot pictures inside the Geological

Museum, the Archaeological Museum, the National Museum, and the Historical Museum of Krakow was obtained. Various exhibits, including models of historic Krakow, collections of rocks and archaeological finds, sections and geological maps, reconstructions of prehistoric settlements, archival maps, paintings and photographs of Krakow in past centuries, costumes and props associated with traditional rituals, preserved house interiors and experiments carried out in the research laboratories of the Jagiellonian University were filmed in these establishments. The film uses rich screen graphics, including subtitles and animations to facilitate the understanding of the presented scenes. The idea behind the film was to encourage students to reflect on the "biography" of Krakow by showing the spatial structure of the city, causal relationships between different phenomena, setting the structures observed today in a historical context, and perceiving urban systems from the archaeological and geological perspectives.

The film "Exploring Krakow with Teme" and its online platform have the following characteristics attributable to transmedia:

Responsiveness (responsive web design) and multimedia nature, which means that the film can be played back on a computer, TV, tablet, phone, and mobile devices with different screen resolution (Fig. 1).

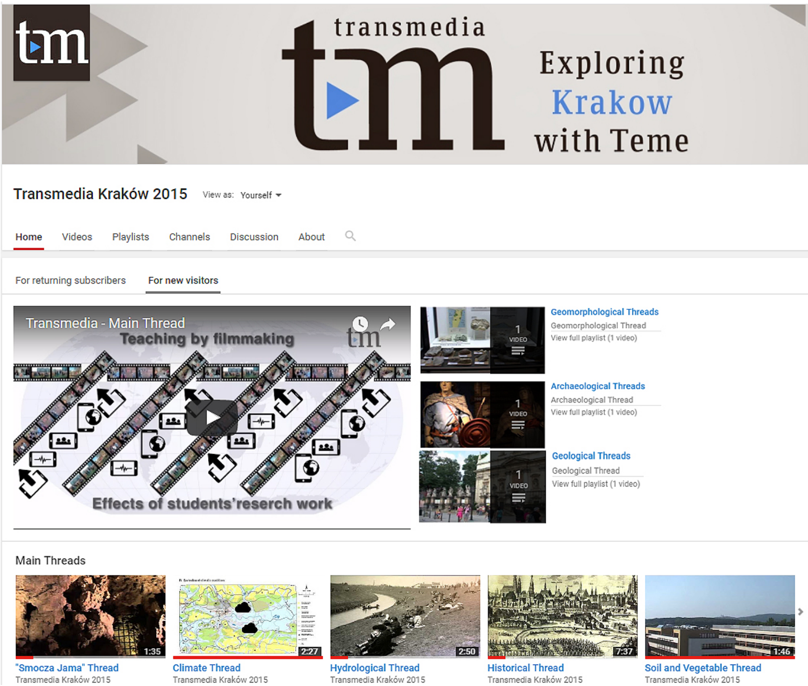

Figure 1. The Google+ YouTube platform with the uploaded transmedia film, along with background material.

Complexity and multi-threading, which means that both the main movie lasting 19’28’’ and presenting the keynote of the video and eight subplots included in the main picture using different narrative perspectives were placed on the Google+ You Tube platform. A feature of the narrative is the existence of causal relationships between the described events, which implies the appearance of points of entering the subplots of the film. The subject of the subplots (movies) is varied. The films talk about Krakow’s archeology (4`57``), its history (6`17``), the geological history of the city area (4`08``), as well as about geomorphology (1` 55``), climate (2`27``), hydrography and hydrology (2`50``) and soils, about the world of Krakow’s plants and animals (1`45``). One of the subplots is a movie about the dragon’s cave (1`35``). The multi-thread plot does not hierarchise subplots, and their omission does not limit the reception of the main film. Threads or subplots are an extension of the signalled main issues of the film (Fig. 2). All the students are expected to watch the main story. It is the students` task to pick a subject related to the main plot or subplots, and elaborate on it, creating new content in the form of a movie, an image, a recording, a text document or a presentation. There is no definite end or a beginning of the movie and it can be endlessly expanded.

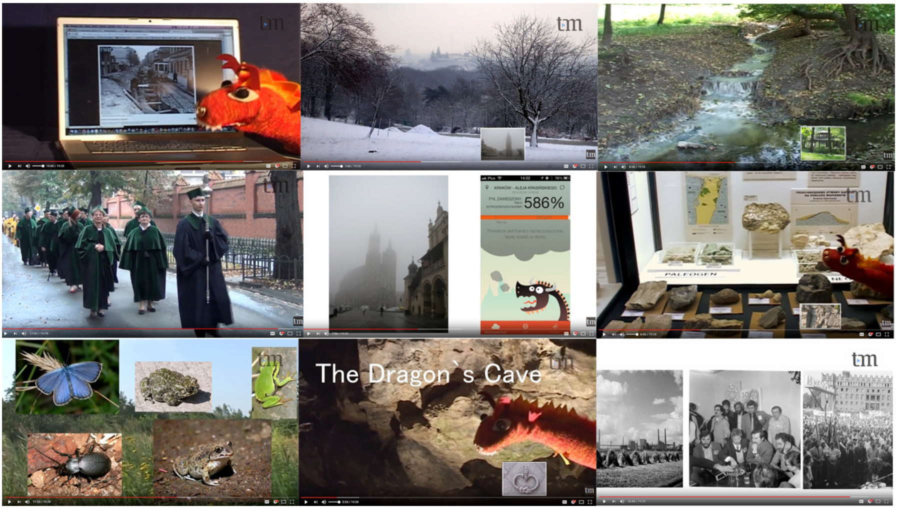

Figure 2. A frame from the subplots of the film “Exploring Krakow with Teme”. The images visible in the lower right corner of the frame indicate entry points to the subplots.

Participation and interactivity, which means that the students taking part in the course as transmedia recipients contributed to the story (the main movie) by adding additional subplots. Thus, the students became *prosumers* (i.e. producers and consumers), although perhaps it would be better to call them *crecipients* (creators and recipients) since the issue concerns education, and not commercial activities. It was them that had planned and collected media materials in the area, and edited and added their videos to the Google+ You Tube platform. The films whose creators are students deal with various aspects of Krakow's space and bear the titles: "Important buildings in Krakow," "Air pollution in Krakow", "Polish culture seen by foreign students", and "Krakow Technology Trail", "The most interesting places in Krakow", "The History of Krakow Jews", "The Jagiellonian University as seen through the eyes of foreign students".

Mobility and flexibility, which means that the students were able to watch the movie on any platform/s depending on the time, place and availability of digital devices.

The main plot was produced by the professional advertising agency AplausMedia (www.brawwwo.pl/), while the IT architecture was provided by LavaVision (www.lavavision.pl/).

2. *The virtual educational cloud*

Classes in the computer lab are a transition from the virtual reality in a transmedia film to the real world. These are seminars conducted using an educational cloud created on a virtual Google disk and on the interactive university e-learning platform called "Pegasus" (the Jagiellonian University). The seminars are conducted using blended-learning and mobile-learning. Sample files included in this folder comprise text and graphic documents intended for joint editing by students; webquests intended to be solved during the seminars; instructions for performing laboratory exercises; maps with photocodes (QR Code) for field classes. The purpose of the seminar classes is to find valuable Internet information resources, acquire proficiency in the creation of files in different formats, notice problems, engage in discussions, and co-edit texts and infographics. Students can individually explore the problems depicted in the film and look for new threads to explore.

3. *Trip – field work*

Field work allows for students' direct contact with objects shown in the film, a personal reflection and an assessment of the observed landscape. During field work, the participants use mobile devices (smartphones, tablets, Sat Nav with camera, digital voice recorders, smart penn – digital pens). The materials required for the class are uploaded to the cloud by the teacher, e.g., thematic and historical maps, sketches, section drawings, archival photos, pictures, drawings, diagrams (Pietrzak, 2016). The teacher creates a map with the route of the field trip, where they place QR codes to the mentioned resources or websites. During classes on „Transmedia in Science Education" and the trip around Krakow students can browse pictures from the resources of the National Museum, the Historical Museum of the City of Krakow, The National Digital Archives, and map services of Krakow.

During the trip the teacher refers to the facts and events shown in the film. For example, after visiting the „Dragon's Cave" and observing the tectonic horsts, students verify their field observations against the maps available on the website of the Geological Museum. Links to the Archaeological Museum make it possible for students to discuss the relationships between prehistoric and historic settlements and the geographic environment. Observations of the city from the vantage point on the royal hill allow the comparison of historic paintings and photographs with the contemporary landscape. This is a starting point for assessing architectural and functional changes in the urban space. In this way, at subsequent points of the tour, web-based sources deepen the understanding of places, buildings and urban systems.

4. *Experiments*

To achieve the full understanding of natural phenomena, classes were conducted in the geomorphological laboratory of IGiGP UJ using experiments and natural demonstrations. Students create instructions describing exercises and laboratory experiments before classes and upload their descriptions into the appropriate folder. The photos from demonstrated experiments, available in the cloud, constitute revision material and are uploaded after classes. The experiments whose observations and measurements require many hours or several weeks of observation are monitored and recorded, whereas pictures or podcasts are placed in the cloud.

5. *Collaboration in the project movie maker*

Classes were conducted in a computer lab in order to accustom students to the way of preparing the script, the shooting of films in the field, and to the post-production phase. Different educational techniques were used during the classes, among others, microteaching, webquesting, e-portfolio and snapshots. Also discussions are an important component of classes, e.g. those using techniques of creative thinking and different models of deep reflection (e.g. Edward de Bono's, Terry Borton's). A joint screening of the films made by students and making them available on the transmedia platform is the final result of these classes. Subsequent course participants will come into contact with the main film and its many new subplots. The educational content of the course broadens from year to year, however, it is never known in what specific topic areas. This is an interesting challenge for the teacher running the course.

Theories of teaching vs. education with the use of transmedia storytelling.

What is the point of making transmedia movies? What educational purposes are they to serve? Many publications call for the availability of open educational content and educational materials, and for teaching information skills, i.e. working with information, searching, evaluating credibility, verifying sources, processing and critically analysing information. Mass open on-line courses, which appeared in 2012, are an example of a recent revolution in the approach to teaching based on the information resources of the Internet. Since information resources continually improve and change, the selection of quality content becomes a key competence.

Thus, how can we organize the transfer of knowledge, create conditions for its self-exploration, and provoke teamwork and effective communication?

Three concepts of learning were used in the "Transmedia in Science Education" course, i.e. a) the behaviourist concept of the programmed teaching method implemented by the teacher through the content and tasks posted on the university interactive e-learning platform "Pegasus" (the Jagiellonian University); b) the constructivist concept, where students independently develop their system of knowledge by watching a transmedia movie and producing their own movies, thanks to the direct observations carried out during the fieldwork and natural experiments performed in the laboratory; c) the concept of connectivism, through collaboration in network communities, e.g. teamwork in a virtual cloud, collaboration in projects. Here, an important element is the acquisition of skills of efficiently finding information on the web and sharing it during the co-editing of documents, podcasts and infographics (Fig. 3). Collaboration and communication are important elements of constructivist teaching.

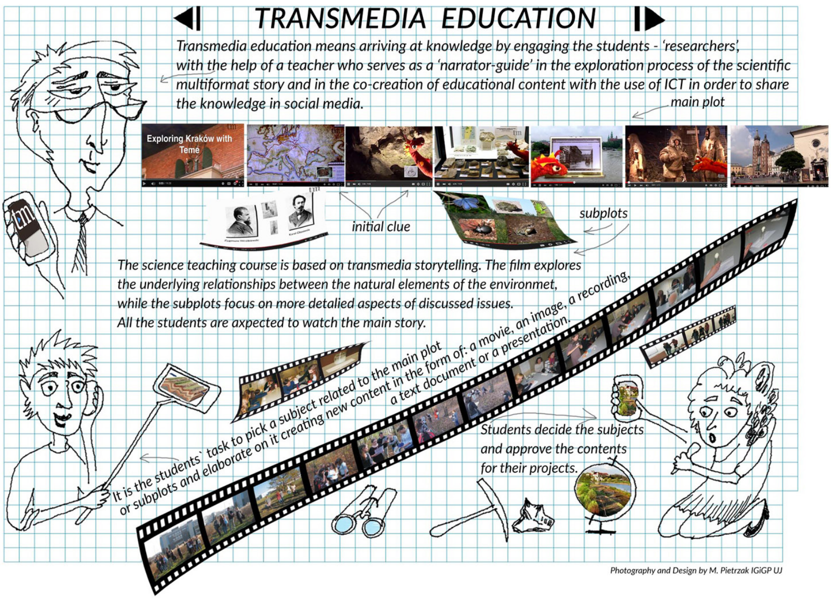

Figure 3. The infographics showing the overall concept of transmedia education.

Summary

The main reason for the use of the media was the emergence of a generation of digital natives, for whom virtual reality is a real part of life. In transmedia nature education we stimulate the involvement of students by setting off from a virtual world (the film) and heading for the real world.

Does the idea of using a transmedia film during an academic course mean focusing on educational means or objectives? My intention was to promote the idea of transmedia education as engaging, creative and social approach. Introducing students to a deliberately prepared transmedia story, the teacher arranges watching a movie in a methodical way so that its content is a subject of scientific discussion and individual critical evaluation. In the case of nature films, they should relate to the region (structure, phenomenon) known and available to students, but they should show it from perspectives hitherto unseen and unknown. Since, on the one hand, students can experience the viewed images directly, take measurements and perform experiments confirming the veracity of the contents presented in the film whereas, on the other hand, they can see and discover facts they have not suspected, and they have found their confirmation in hitherto unknown sources of information.

Transmedia natural science education does not end with watching the film, but has its thematic continuum in field exploration, in laboratories, classrooms, and must be integrally associated with them. Multistage education forces students to learn the in-depth perception of the surrounding reality, ask questions, and realize the role of requited communication. The film is a tool leading to a goal, it is not a goal in itself. The film is part of the course whose formula is unique because it requires students to think critically about new media, and teaches media literacy from a dual perspective, i.e. both as a recipient and creator. The necessity to create their own film forces students to become involved, share ideas and collected materials. It enforces the necessity to remain in the "real world". It requires communication in social networks and collaboration while working on podcasts, presentations, albums, or documents. It also enforces cognitive, methodological and axiological reflection, i.e.: What am I doing? Why am I doing it? For whom am I doing it? How to do the job? Is the purpose of the job valuable?

The virtual world is like a huge mirror reflecting the actual reality of many people and the heritage of humanity (not of everyone and not of everything because the mirror is, after all, limited). In the real world, when looking around we can see only the closest people and objects. Looking into the mirror, we can see the world of other people and matters, other times and places. We need the virtual world (of multimedia, transmedia, the Internet) to broaden our horizons, but it is still only a reflection of reality. We can fully experience nature in the contact of all our senses with it.

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The Use of Video to Analyze Chemical Experiments with Fast Course

Introduction

We have informed you about the method of how to evaluate experimental activity, which brings new knowledge that was hidden to the human eye and thinking before. We have chosen the experiment with extremely fast or even explosive course. If we record the experiment by camera and analyse particular slides, we enable learners to support their thinking by visual insight. For this reason, we have chosen an experiment showing the chemical reaction during the activity of a spark-ignition engine. During the experiment we can present how to do the experiment more efficiently. The whole systematic procedure is the focus of this work. The realization of the experiment in a new inovative apparatus is the basis. After that, we continue with the description of what we have recorded and highlighting chosen slides.

The chosen experiment is significant even from an applicative point of view. During it, we can not only gain more effective insight into the principle of the work of a spark-ignition engine, but also we can emphasize other important issues which are connected, e.g. adjustment of fuel (the use of additives) or ecological issues (function of catalytic converter).

The principle of evaluation of data is to use the recording and then careful analysis with the help of a suitable computer programme e.g. VirtualDub. This enables us to see particular slides that correspond with particular points of action. (Rychtera, Hásek, 2014)

The description of the improved apparatus

Our task was to create an apparatus which meets the requirements of didactic aids. Průfa defines a didactic aid: 'a didactic aid is an object which mediates or imitates reality and enables learning.'

An interesting definition of didactic aids comes from Dostál:

- The basis of aids is matter which sends signals
- Into this matter we put curriculum
- Didactic aids imitate reality
- Didactic aids require realization with the help of technology; understanding is encouraged with the help of the use of our sense organs
- Didactic aids are either used for demonstration or students can manipulate with them

- Didactic aids are means of communication between teachers and learners
- Didactic aids motivate learners and activate them
- Didactic aids are the border between unintentional and intentional attention
- Didactic aids help to overcome tiredness that is a natural reaction of our body against exhaustion or a response to monotony and boredom
- Didactic aids can be used in all phases of teaching.

We have set specific rules for didactic aids

- Simplicity in preparing the aid
- Easy and fast manipulation
- Safety
- Transparency
- Low price

The basic part of our didactic aid is a transparent cylinder from polymethyl methacrylate where the reaction takes place and there is an ignition spark which causes ignition of the mixture in the cylinder.

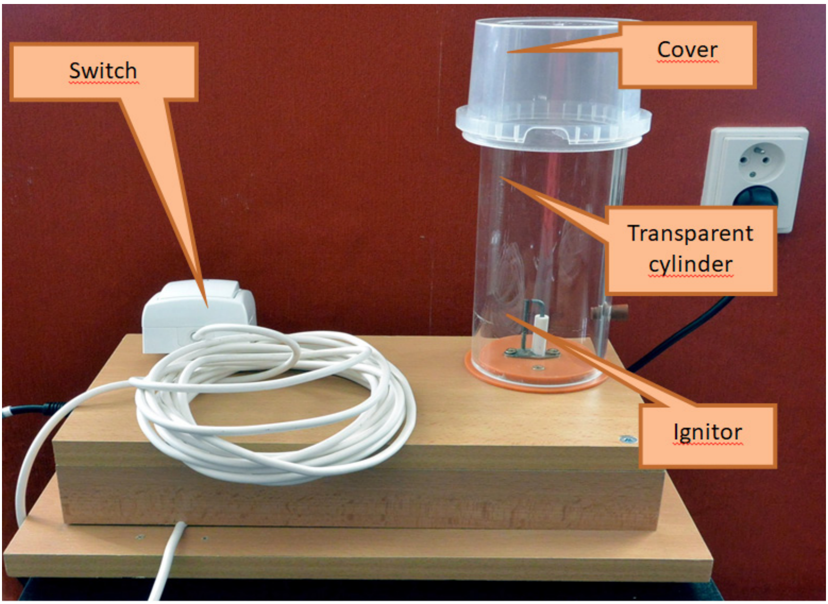

Figure 1. Model of spark-ignition engine. It is closed and prepared for an experiment (photograph was taken by authors).

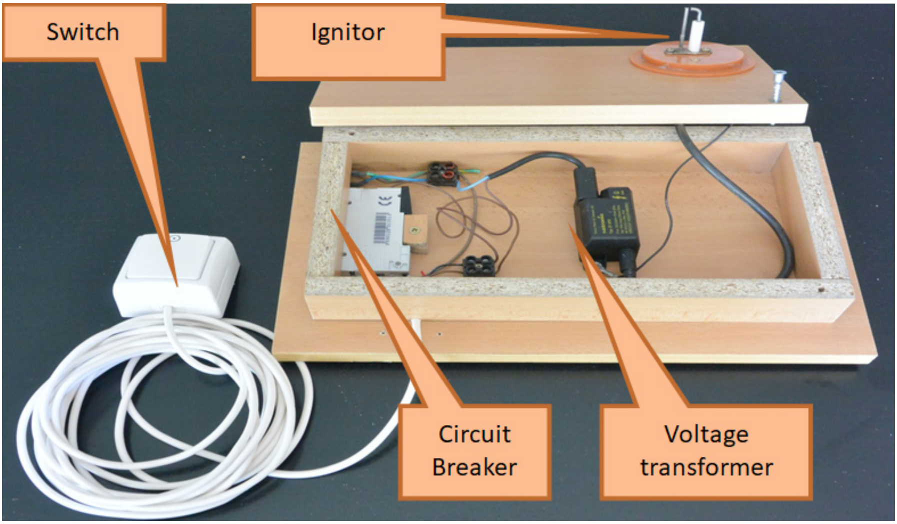

Figure 2. Model of spark-ignition engine. It is opened and not complete (photograph was taken by authors).

The whole apparatus is powered by alternating current 230/50 Hz connected with a removable cable. The entrance to the device is through a circuit breaker, which ensures safety and works as a switch.

The key part of the apparatus is the source of the spark – ignitor. This part comes from a gas boiler which ignites a burner. High voltage 13 kV in the ignitor is due to the voltage transformer, which was originally for the gas boiler as well. This voltage transformer and the circuit-breaker are placed in a laminated box. The switch activates the spark. For safety reasons the switch is on a 5m long cable.

The other important component is a transparent cylinder from polymethyl methacrylate with a volume of 1000 ml which is open on both sides. The cylinder stands on the laminated box; the bottom part is within the reach of the ignitor. On the top part there is light plastic cover so that it can fly away during ignition in the cylinder. 5 cm above the base of the cylinder, there is a hole with a diameter of 6 mm so that the cylinder can be filled with gas. If it is not filled, it is covered with a rubber cap.

We start our experiment by preparing the apparatus and plugging it in. We use suitable fuel and put it into the cylinder. Suitable fuel for our experiment is:

1. Hydrogen – We gradually inserted 300, 450, 600 and 900ml to the side hole in the cylinder with the help of a syringe.
2. Natural gas -We gradually inserted 150 ml and 300ml to the side hole in the cylinder with the help of a syringe.

3. Butane - We gradually inserted 20,30,40 and 50ml to the side hole in the cylinder with the help of a syringe.
4. Unleaded petrol with octane number 95 – We have put a beaker with 25ml of petrol to the cylinder and let the gas evaporate.

After putting fuel into the cylinder we pressed the switch and activated the spark which caused ignition of the fuel. Essential activity was the recording of the ignition with the camera Nikon N1 which enables recording 400 shots per second.

An analysis of recording

For our needs we could use a camera with recording 25 shots per second although more efficient is recording realized at a higher speed e.g. 400 shots a second.

An ignition of fuel is a very fast reaction and that is why it is important to record as many shots as possible for the following analysis.

It is important to shoot when it is gloomy and have a dark background because then you can have the best pictures possible with clear colour of the flame.

For dividing recording into individual shots we used the application "Free Video to JPG Converter" available on http://www.dvdvideosoft.com/

The following pictures are examples of shots from the experiment.

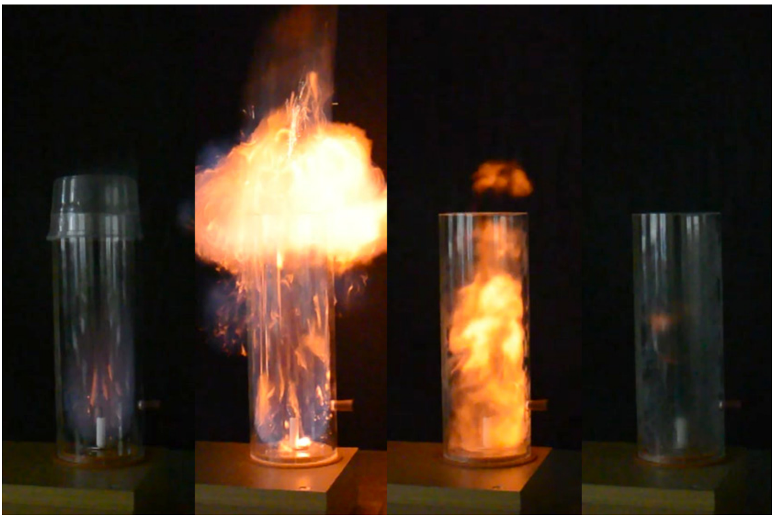

Figure 3. Ignition of hydrogen – 0.0025s after ignition, then after 0.0050s, 0.0325s and finally after 0,0500s (photograph was taken by authors).

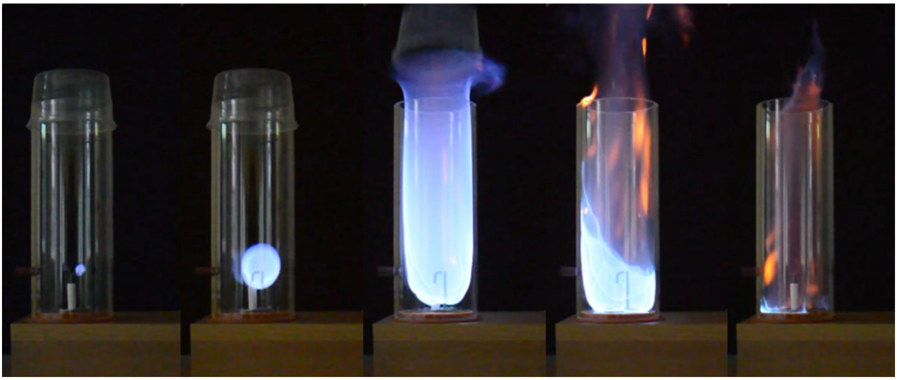

Figure 4. Ignition of petrol N 95 – 0.0025s after ignition, then after 0.0100s, 0.0250s, 0.0450s and after 0.0675s (photograph was taken by authors).

Division of the recording into shots gives us important information. If a camera records 400 shots per second, there is one shot every 0,0025 second and we can measure the exact time of the explosion.

An experienced person needs only about 2 minutes to divide the recording into shots, so we can use it even during our lesson. Or students can do it which is beneficial from an interdisciplinary point of view.

The use of analysis

If we safely and properly carry out the experiment and have the recording, both teachers and students have enough information which improves the learning process. This information can not be gained just by observation.

In addition we gain:

- An insight into the act of ignition
- The possibility to measure reaction and its phases
- On the basis of the colour of the flame we can determine the temperature (we can use a scale, see fig. 5)
- By observing colour we can assess the quality of burning (see fig 6.)
- As a more advanced alternative we can also guess the composition of fuel.
- According to speed of reaction and the colour of the flame we can also determine optimal concentration of fuel in a cylinder and compare it with optimal concentration set in chemical tables.

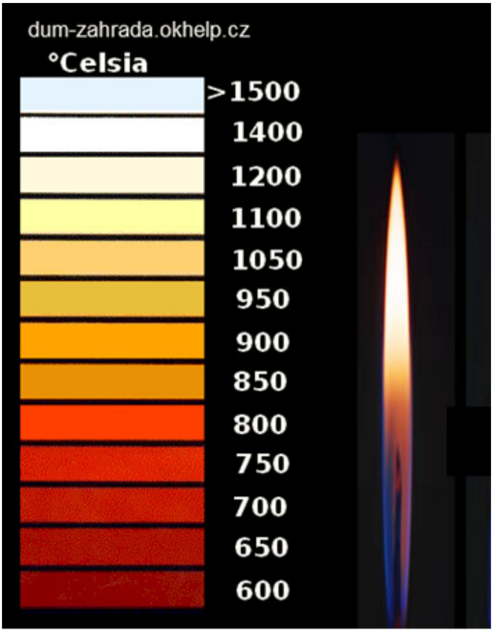

Figure 5. A temperature scale set on the basis of the colour of flame (http://dum-zahrada.okhelp.cz/forum/viewtopic.php?f=10&t=296&p=418).

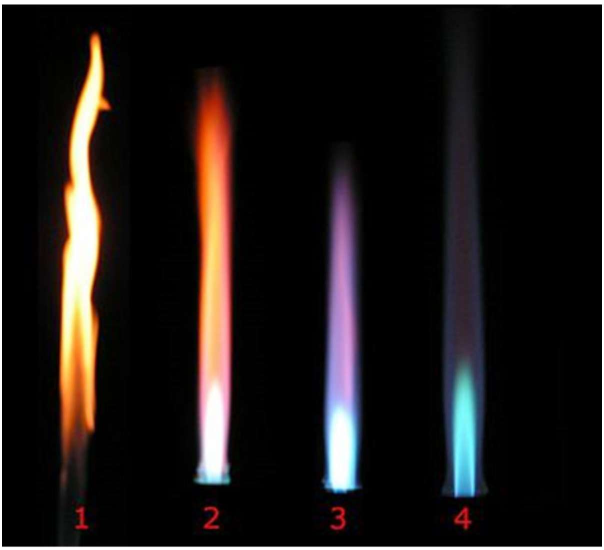

Figure 6. A colour scale according to the quality of burning. On the left – the burning with the lowest quality, on the right – the perfect burning (http://dum-zahrada.okhelp.cz/forum/viewtopic.php?f=10&t=296&p =418).

Inquiry-Based Science Education (IBSE)

IBSE stands for Inquiry –Based Science Education. Translation to Czech has not been set up to now. The most common translation is exploration-oriented nature education (Stuchlíková, 2010) or

exploration-oriented teaching (Papáček, 2010). This method means departure from the way of education where a learner would only memorize facts. In IBSE we put the accent on understanding and a logical process in gaining skills. The point is to involve students in a process of discovering scientific rules and the connection of information, to develop critical thinking and to support positive attitudes to natural sciences (Kyle, 1985,Rakow, 1986). The emphasis is on exploration not on memorizing facts (Papáček, 2010).

When we planned and realized our experiment, our aim was to involve students in exploration. The combination of knowledge gained during theoretical lessons and those gained during an experiment with the following analysis is essential. We want students to figure out certain natural relations and then be able to adjust procedure and parameters. On this condition we use Inquiry-Based Science Education.

We can even make use of a mobile phone as a means of education and not only as something which disrupts a positive atmosphere during lessons.

Conclusion

After assessment of the mentioned approaches to experiments, we can conclude:

- We mentioned nontraditional methodology of doing chemical experiments which enables us to gain new information. We would not be able to gain the information in other way because of the imperfection of our sense organs.
- Thanks to the wide use of ICT (smartphones, tablets, cameras) this method is a way how to use IBSE at primary and secondary schools.
- Our next research will be focused on searching for new experiments which would improve the described method.

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Implementation of Mobile Technologies into Laboratory Work at Lower Secondary School Level

Introduction

Regarding fast development of information and communication technologies (ICT) we often meet their integration into learning. The precondition for introduction of ICT into learning is simplifying the learning process, speeding it up or making it more effective. The use of ICT should also enable activities which would be impossible otherwise.

Recently the attention has been focused on implementation of mobile technologies into learning. The boom of using mobile technologies in lessons is proved by the introduction of a new independent term "mobile learning" (M-learning) which represents learning supported by mobile technologies themselves (Rosman, 2008). Mobile technologies are not only represented by mobile phones, laptops or tablets, but also by dataloggers or voting equipment and many other portable devices. There are many ways how to use these technologies in lessons: "...through mobile phones to support learning between schools and museums, to context-aware technology for field trips and tourist visits" (Walker, 2006). Regarding special needs of teaching sciences, mobile technologies can be also used straight in the classrooms, e.g. as support of laboratory work, during field trips in factories or natural reserves.

The topic of this chapter is the support of Chemistry education using mobile technologies. In our case we focused on the possibility to use tablets while doing laboratory work in Chemistry. Tablets served as means to make video records during Chemistry experiments by the pupils themselves while solving laboratory tasks. Then we deal with the possibility to build inter-subject connections with teaching IT lessons which naturally offer the use of mobile technologies. We also think that the use of mobile technologies in inter-subject connection of Chemistry and IT leads to higher levels of ICT integration.

Mobile technologies in science education

In connection to implementation of mobile technologies into learning the schools face a challenge how to modify learning goals and teaching methods regarding the use of all the chances these technologies offer. The ways how to implement them into teaching are pictured in so-called SAMR model (The Substitution Augmentation Modification Redefinition Model, see Figure 1). This model pictures four levels of integration of technologies with different impacts on changes in learning.

The lowest level "substitution" represents the use of technologies as replacement of traditional media (books, textbooks) in learning, thus not bringing any new functional elements. The second level "augmentation" shows the use of technologies in the same function as traditional media with some improvement, e.g. testing while using programmes which can evaluate the tests themselves (compared to traditional paper tests). The third level "modification" represents certain modifications of tasks according to the abilities of new technologies, e.g. producing seminary works not only with texts and pictures, but also with video samples or music, or in group work using e.g. GoogleDisk. On the highest level "redefinition", the potential of modern technologies is maximally used and they have there irreplaceable and unreplaceable function, e.g. making ePortfolios (Goodwin, 2012).

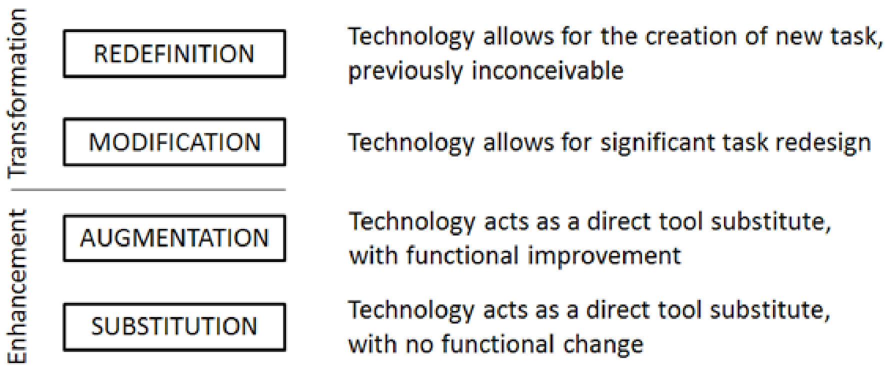


Figure 1. SAMR Model of Technology Integration (modified from Goodwin, 2012).

Mobile technologies can bring teaching contents with multimedia elements, not only as i-textbooks or e-textbooks, but also in the way of various simulations which allow to gain various skills in addition to knowledge. Then they support active learning and pupil-oriented teaching, they enable to make records of their learning process and record the data in its course. Thanks to their mobility they provide learning anytime anywhere with the possibility of immediate contact with classmates, teachers or specialists in the subject matter which helps to "contextualize learning", i.e. solving the problem in its real conditions (Neumajer, Rohlíková, & Zounek, 2015). These chances can be fully used while teaching science, esp. in research-oriented lessons (Starková & Rusek, 2015; Ahmed & Parsons, 2013).

Pupils can e.g. investigate plant features right in the open air, make their detailed photos or time-collecting videos of plant growth, thanks to a ready-made guide complete their observations with information (Lai, Chih Hung, et al., 2005), or – if needed – they can look up other information in available sources. Laboratory lessons can be supported in a similar way – paper protocols with instructions for laboratory tasks can be replaced by e-protocols, where the students can fill in their answers in words as well as accompanying them with photos and videos of the process of the experiment; using sensors and dataloggers they can immediately record and process their data obtained during the experiment; before the experiment itself the pupils can also try a simulation (Machková & Bílek, 2013) or a virtual laboratory (Glavinic, Kukec, & Ljubic, 2007) and they can compare the obtained information with the real experiments, etc. All these e-protocols can be handed in to the teacher on the joined storage, where they should be accessible to other classmates; this storage can be also a place for comments and discussions on the experiment and obtained information, not only from the teacher but among the pupils as well. All the materials made in this way can be included into pupil´s e-portfolio (Hanzalová & Hubálovský, 2016).

Using video in lessons

Using video records in learning has had its long history, it has been appearing since the 30´s of the 19th century (Auerswald, 1953), firstly as educational films, i.e. slides for explanations. Video records were included into lessons to increase the clearness, to make the explanation more attractive or to show information faster. From information posters of Masaryk University on the topic called Video in Lessons (Information System of Masaryk University [IS MU], 2016) we take more contemporary possibilities how to use a video:

1. Video tutorials and showing the steps
2. Listening exercises
3. Video training (work during the videos – answering questions, working on tasks)
4. Webinars (online seminars on the internet)
5. Recording pupils´ performances
6. Motivating videos
7. Video conference
8. Subtitles for videos
9. Video textbooks
10. Records of lectures of invited specialists

Video records have another specific use in teaching science. E.g. the video record is used showing some activities or processes as a replacement of a field trip, if it shows a production process or a natural reserve or as a replacement or supplement of a real experiment (Chroustová, Machková, & Hanzalová, 2016). In case of experiments the video record is especially used for dangerous, expensive, time-consuming or environmentally harmful experiments as well as for those which cannot be done due to the lack of equipment in the school (Keusch, 2004). The video record can point out details of the experiment and focus pupils´ attention on particular objects (e.g. parts of the equipment). With its use we can summarize the real experiment in a short time period or show the pupils the wrong laboratory uses (Keusch, 2004).

From the above mentioned ways how to use videos in lessons we are interested in the fifth possibility – Recording pupils´ performances, where the authors think about its use in humanities and they see the teacher as the cameraman. *"In subjects teaching linguistics, didactics or presentation skills it is suitable to provide pupils with feedback. Video is a suitable helper and thanks to the tools enabling to comment that particular moment of the video record, the pupils obtain even more effective feedback"* (IS MU, 2016). This approach enables us to give pupils effective feedback, a chance of self-reflection and self-evaluation based on watching and analysing the video records of their performance. However, in our work we focused on situations where the video records are made by the pupils themselves during their work in their science lessons while working on laboratory tasks.

Pupils´ videos in lessons

A video record of laboratory workshops recorded by the pupils themselves is an important source of information both for the pupils and the teacher. It serves not only as an additional part of an electronic protocol recording the process of laboratory activities, e.g. the experiment, but also as a source of mistakes and failures in their laboratory work. It also shows what the pupils pay attention to and what is irrelevant for them; their comments also reflect pupils´ knowledge (Chroustová, Machková, & Hanzalová, 2016). Thus these video records can be used for feedback as well as for development of laboratory skills (Towns, et al., 2015). Galloway and Bretz (2016) recommend using the combination of pupils´ video record and the record from the laboratory made by the third party to reflect the laboratory work in a more complex way.

Videos made by the pupils can be also used to support inter-subject relations. Pupils can process their records in their IT lessons where they can practise work with videos, cutting and including introductory pictures or subtitles. They can also involve learning foreign languages when pupils can prepare foreign subtitles to make the videos international, or it is possible to include text making in original subtitles into mother-tongue lessons pointing out stylistics (Chroustová, Machková, & Hanzalová, 2016).

Before we start recording the videos with pupils in their lessons, it is necessary to think about practical aspects connected to this activity. It is not only getting the devices (school equipment where the teacher has to check its functioning and s/he has to be able to operate them well, or the pupils´ devices, so-called BYOD when the pupils have to be informed in advance), but also the goals of recording, exact demands and instructions or following legal rules. In the Czech Republic we need the affirmative declaration made by the statutory agent for making photos or video records of the child. An exception is any material for scientific purposes. Most Czech schools have solved this in so-called informed affirmation which the parents sign for the school or they express their disagreement when their child is accepted for the studies at that school (Chroustová, Machková, & Hanzalová, 2016).

Making scripts for pupils´ videos

Placing the pupil into the role of the video record author in the laboratory gives the video records added value in the way of feedback which they can give about their laboratory work, as we have already mentioned above. In the previous work (Chroustová, Machková, & Hanzalová, 2016) we proved that making the instructions more precise leads to better worked-out videos especially from the technical point of view; in this following work we think about the use of a script made in advance, a script of shots of laboratory activities – supposing we obtained better results in the contents as well.

While examining available scripts for laboratory workshops in Chemistry we found out that most of them are just manuals for the experiment, so they are not scripts suitable for recording videos, they do not point out what the pupil should concentrate on or what will take how much time. That is why we extended our search to find any scripts for videos with educational contents.

There are several ways of writing scripts for videos. Most often mentioned one is so-called 3 act structure (Cattrysse & Gambier, 2008) which is originally designed for film scripts – it is a structure with a plot and story. This one is not suitable for our purposes.

Another way is to write the script in lines, i.e. first to write the background and plot and then the texts (Moreno & Tuxford, © 1982 – 2016). This approach did not seem ideal either. It is suitable for dialogues or theatre plays, where a short plot line (including place for improvising) has more text. This way would be suitable for making dialogues or simple scenes e.g. in lessons of foreign languages or social studies.

Finally we chose the form of a table (Sandbox, 2014). It is a model which is also used by well–known servers with educational videos. Specifically it is the well-known Khan Academy. In the video (inmydreamz8, 2013) we can see how to make a script like this and how to work with it. This type of a script is written into a table of several columns. In one line one activity is described, being characterized by various factors – these can be found in the columns. The number of columns depends on the author and their needs. There can appear activities, technical background, type of shot, length, text etc. The simplest script of this type has two columns where there is mostly often Video (Screen Capture) + Script. We chose a three-column version according to the offer in the video which has the following columns: Step + Action Onscreen + Audio.

Initial conditions of the Case Study

The research was made in one class of the fourth year of eight-year grammar school (pupils aged 14-15) in the lessons of Chemistry and ICT. In Chemistry lessons (having been taught here for the second year) there are also double-lesson laboratory workshops. Two groups alternate (every week one group has their laboratory workshop in Chemistry, while the other group has their laboratory workshop in Biology at the same time). The structure of both the groups is very similar; including average school grades on the pupils′ school certificates (see Table 1 – difference in number of pupils in group B in the third and fourth year is caused by a new pupil). ICT has been taught here for the first year in the amount of 2 lessons a week. For the ICT lesson the class is divided into the same groups.

- Group A – 6 girls and 8 boys, one of them participated in Chemistry Olympiad.
- Group B – 5 girls and 10 boys, one of them participated in Chemistry Olympiad.

Table 1. Pupils′ Results in Chemistry (Chroustová, Machková, & Hanzalová, 2016).

	Grade	1	2	3	4	5	Average
Group A	at the end of the 3rd year	8	4	2	0	0	1,57
	in the 4th half-year	5	7	2	0	0	1,79
Group B	at the end of the 3rd year	7	6	1	0	0	1,57
	in the 4th half-year	4	9	2	0	0	1,87

Laboratory workshops in Chemistry were led by a qualified teacher with 13-year-long experience who has been using ICT in her theoretical lessons normally (presentations, quizzes, video records of experiments). However, she used them in laboratory workshops during our research for the first time. (Chroustová, Machková, & Hanzalová, 2016)

ICT lessons were led by a qualified teacher with 3-year-long experience. She tries new approaches in teaching. She welcomed the work with the videos from Chemistry lessons.

Process of the Case Study

Altogether video records of five laboratory workshops were collected. The analysis of the first three laboratory workshop video records was described in a detail in the article (Chroustová, Machková, & Hanzalová, 2016) where we watched the influence of optimizing the instructions and recommendations for pupils′ video recording during their laboratory workshops on the quality of the final video records from the point of contents as well as from the point of its technical processing.

The results of this study showed that processing this material (video record of the work in the laboratory itself) based only on variety of detailed instructions and the manual for laboratory workshops is rather difficult for the pupils – there are "blind spots" in the videos, repeated shots appear several times, the video is often not focused or some shots are recorded carelessly, some groups did not record all the parts which should follow the other steps in the experiment. Due to a lot of noise in the laboratory, the comments are little understandable or they are missing completely. Videos are suitable for the pupils′ work analysis made by the teacher (which is highly time-consuming due to their length), but they are not suitable for the pupils as a study material. Their following processing into an educational video in ICT lessons would be very difficult.

Based on this result we made another optimization of instructions for video recording and we chose making the script of individual shots and comments before starting the laboratory workshop as another factor to influence the quality of final video records. We watched the influence of a ready-made script on the quality of the final video records of the experiments during laboratory workshops 4 and 5. The sequence of all particular steps of the case study is shown in the scheme in Figure 2. Steps 1 – 4 were described in a detail in the publication (Chroustová, Machková, & Hanzalová, 2016), steps 5 – 10 will be described in the following text.

In this part we will deal in a detail with the fourth and fifth laboratory workshops. They are analysed separately as a comparison of group A, who worked without the use of a ready-made script, and group B who had made the script for recording the videos of experiments in advance.

Group A had a chance to view several shots recorded in their previous laboratory workshops and in their ICT lessons pupils discussed their quality, common mistakes and ways of improvement – it was just the analysis of technical matters, not interference to the experiment itself. Group B also discussed the videos made in their previous laboratory workshops. Moreover, they got the task of the following laboratory workshop and their task was – based on their previous experience and tasks – to think out and make a script of their video record which they would make during their laboratory workshop. For making the script they used the above-mentioned table.

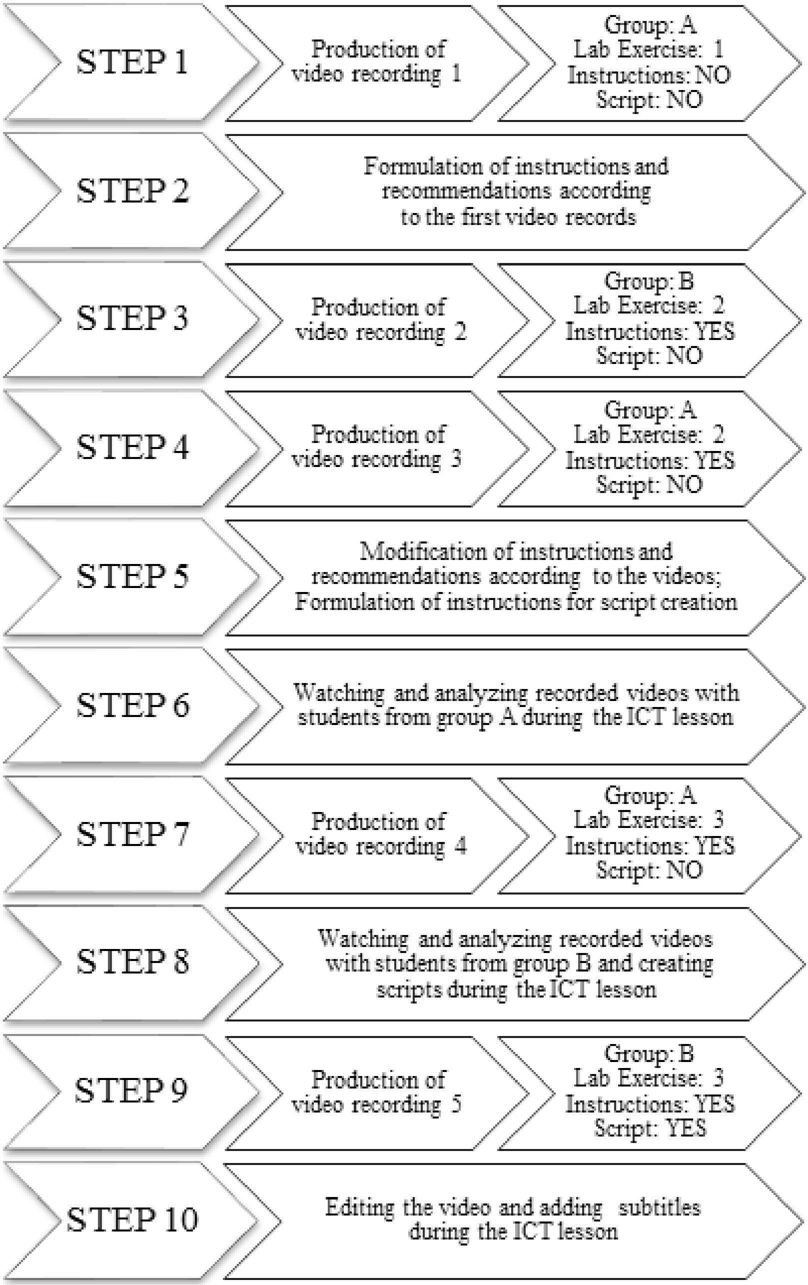


Figure 2. Scheme of Process of Case Study.

Both the groups A and B worked in the laboratory following the same task. The topic of the laboratory workshop was the properties of vitamin C. The goal of this laboratory workshop was to do two experiments when the pupils were examining (1) solubility of vitamin C and (2) its redox properties. In the video records the pupils were to record the process of the experiment from preparing the equipment and chemicals to the conclusion based on the observed changes. The record of the first experiment was to show different solubility of vitamin C in dissolvents of different polarities – in oil (nonpolar dissolvent) and in water (polar dissolvent). In the record of the second experiment there were to be shown changes in colour which appear during redox reaction of vitamin C with the mixture of dissolvents of Ferric (III) chloride and Potassium ferricyanide. In this reaction first vitamin C reduces Ferric cation (Fe^{3+}) into Ferrous (Fe^{2+}), which then reacts with Potassium ferricyanide while dark green Iron (II) Ferricyanide (Ferrous Ferricyanide) originates and after a while it changes into dark blue Prussian blue. These changes in colour prove the presence of vitamin C in the solution.

Group A

This group recorded the laboratory workshop during the whole case study for the third time. The pupils had basic instructions and recommendations for making video records using tablets (see Table 2) and the task of the laboratory workshop. So the pupils faced neither problems operating the tablets, nor any lack of their functioning. They had divided their roles in their previous recordings (cameraman – commentator, laboratory worker). The activities went on in the standard way and were finished in the set period of time of two lessons.

After finishing the laboratory workshop (step 7) there was held a structured dialogue with the workshop leading teacher and several chosen pupils. From the interview with the teacher it was obvious that using the tablets in the lessons is well-grooved. In comparison to the first recording (Chroustová, Machková, & Hanzalová, 2016) the technology did not interfere with the lesson at all. Pupils spoke about recording in a neutral way – *"First it was fun, for the second time we already knew what to do and today it was just, well, normal. Like a part of the labs."* They also started to be interested in the real purpose of this recording. They asked whether it would be published and whether they could take the video records home on a flash disc.

Table 2. Instructions for Recording (Chroustová, Machková, & Hanzalová, 2016)

GOAL:	*Recording a video record (or a set of video records) to be processed by a computer and in such a way to create an educational video presented on the school web pages*
INSTRUCTIONS:	The video record should contain: – introduction (a presentation of a laboratory work subject), – required equipment, – preparation of an experiment (arrangements of an apparatus, if necessary, preparing chemical substances), – experiment process, recording observable changes, – results and conclusion, evaluation of the experiment, – short description (in words, substituted by subtitles later).
RECOMMENDATION:	1. Video records are to be recorded in the tablet horizontal position (better displaying in its display). 2. The zoom (approaching) is not to be used – it will be better to record the video at initial settings – the resolution will be better. 3. Pay attention to the jitter of the picture (try to stabilize the tablet). 4. Do not perform any quick movements. 5. Avoid blind spaces (if you expect nothing shall happen in a long time period, finish the video record). 6. Avoid inappropriate comments. 7. Do not record anything that is not related to the experiment itself.
NOTE:	If a static picture is enough for an existing part, you can use a photo. Delete video records and photos that should not be processed further.

Group A handed in five raw videos which we analysed from the technical point of view as well as from the contents point of view; i.e. record of essential information about chemical experiments going on. From the technical point of view the video records were of low quality. There appeared mistakes like a moving camcorder, a partial view of the scene, not thought-out setting of the scene and obstacles in the shots which prevented pupils from recording essential information. Word comments were not thought-out, there were factual mistakes or they were completely missing. The pupils had a problem to succeed in recording both the experiments, only 3 working groups were successful in this. In the video records of 2 working groups there is not recorded the whole process of the chemical process (initial substances – reaction – products) but only the result of the whole experiment. From most of the handed-in videos it was difficult to reconstruct the experiments; it means that in general they cannot be further made into an educational video. We can say that the pupils made the same mistakes like when they had been recording in the previous part of the case study (steps 1 and 4).

Group B

Group B recorded chemical experiments during the whole case study for the second time. Right now they exactly knew what they were to expect and all the groups had basic instructions and recommendations for making video records using tablets, the task of the laboratory workshop and the video record scripts prepared in advance.

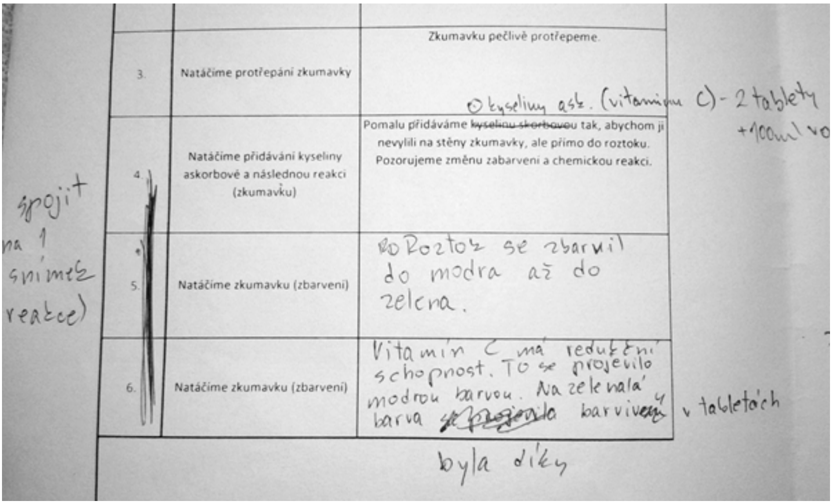
Pupils made the script in their ICT lessons (step 8) based on their own experience (from their previous recording of laboratory workshops) following teacher´s instructions – one week before the laboratory workshop. The script contained identification data – the title of the laboratory workshop, pupils´ names and tablet numbers, for better identification and easier orientation in the following video record processing. The pupils made the plot of the script into a table of three columns:

EXPECTED SHOT – number which the recorded video is stored under in the set device;

DESCRIPTION OF THE SITUATION – short description what is going on in front of the camcorder, a complete part of the chemical experiment;

SUBTITLES – short comment which will be included as a subtitle for the given shot and which replaces the spoken comment during the experiment.

To prepare the scripts for both the experiments the pupils had 60 minutes including setting the task. Pupils made the scripts as working versions knowing they will be used further on and there will be a chance to modify them according to the real process of the experiment. That is why there is space to fill in another text in separate lines. In Figure 3 there is an example of the worked-out script with filled-in notes.



3.	Natáčime protřepání zkumavky	Zkumavku pečlivě protřepeme.
4.	Natáčime přidávání kyseliny askorbové a následnou reakci (zkumavku)	Pomalu přidáváme ~~kyselinu skorbovou~~ tak, abychom ji nevylili na stěny zkumavky, ale přímo do roztoku. Pozorujeme změnu zabarvení a chemickou reakci.
5.	Natáčime zkumavku (zbarvení)	Roztok se zbarvil do modra až do zelena.
6.	Natáčime zkumavku (zbarvení)	Vitamín C má redukční schopnost. To se projevilo modrou barvou. Na zelenalá barva ~~se projevila~~ byla díky barvivu v tabletách

kyseliny ask. (vitamínu C) - 2 tablety +100ml vo

spojit na 1 snímek reakce)

Figure 3. Example of Pupils’ Work with Script.

Pupils from group B were divided into 7 working groups. Altogether seven scripts of each experiment were made. For making the script pupils chose different strategies – 3 working groups only took the instructions from the task of the laboratory workshop and they ignored a more detailed description of the scene. All the working pupils′ groups managed to separate the experiment into logical steps. But only 2 working groups took into account the last shot with presentation of their conclusions of the experiments, the others finished the script at the moment of observing changes during the experiment.

The laboratory workshop went on in a traditional way (step 9), the pupils fulfilled the task in two lessons. Then there was held a structured dialogue with the workshop leading teacher and several chosen pupils. The teacher considered the work of both groups A and B to be comparable. The only difference she identified was that the pupils in group B watched their shots more. Thanks to the previous preparation of the laboratory work it did not have any negative influence on the time process of the laboratory workshop. The time which the pupils would have spent studying the laboratory process they used for watching their videos. One working group tried to record the shots in the highest quality possible so they repeated one experiment. The following remarks were concluded from interviews with the pupils. The pupils reacted in a very positive way to a lesson with this use of tablets. This may have been caused by the fact they were only recording for the second time or because they knew they would process their videos themselves afterwards. They said that they had put much more effort into their work.

Pupils from group B handed in 6 raw video records (pupils from one of the 7 working groups were absent) which we analysed and evaluated from the technical point of view as well as from the content point of view; i.e. record of essential information about chemical experiments going on. From the technical point of view the video records were of higher quality than those records of experiments recorded by group B in the first part of the case study (step 3) and at the same time than video records made by group A in this part of the case study (step 7). From the video records it is obvious that for the recording the pupils used their previous experience with work with the tablet. The camcorder is usually static and essential information which the pupils were to catch is in the shot. Scenes in the shot were more logically structured. The only inappropriate choice was the background for the presentation of changes in colours during the reactions. Two working groups expediently combined dynamic and static screens (photo). One working group only chose a record using static screen. From the contents point of view all the working groups recorded all the essential information in both the experiments. In the video records the whole process of the chemical process is recorded (initial substances – reaction – products). From all the handed-in video records it is possible to reconstruct the experiments well; it means that they are suitable for processing into an education video. The comments of the scenes were thought-out, in some cases factual mistakes and problems with specific terminology appeared.

Obtained video records were then processed in their ICT lesson (step 10). For the processing Windows Movie Maker programme was used. Every pupil from group B processed the video record on their own (i.e. from the raw video records made by one group there were more adjusted videos). During the processing firstly the sound was taken away, thus the noise of the laboratory work was removed. Instead of the sound subtitles were included into the video, in this case pupils put there subtitles in Czech – their mother tongue. While processing their raw video records the pupils followed the prepared script with filled-in notes and modified according to the real experiments in the laboratory.

Conclusion

In the case study we focused on the situation when pupils of the fourth class of eight-year grammar school use mobile devices (tablets) for making video records of experiments during their laboratory workshops in Chemistry. During a traditional laboratory workshop the pupils do the experiments following the task of the laboratory work and they write their observations and conclusions onto a laboratory protocol which they hand in for evaluation to their teacher. Then they do not have a chance to recall their knowledge obtained during their laboratory workshop. The teacher gets the material which s/he can identify comprehension or incomprehension of the set laboratory work from, but this will give him/her no information about pupils´ laboratory techniques while doing experiments, which is an important part of Chemistry education. Both these situations could be solved by making video records of doing experiments in the laboratory workshop. The pupils could use the video record for recalling doing the laboratory task and the teacher could supervise the level of laboratory techniques.

During the period of the case study we included work with the tablets to the laboratory workshops which had been held in a traditional way before. Pupils´ task was to record the process of the experiments using tablets. In the case study we watched two groups of pupils who made video records of their experiments during several laboratory workshops under various conditions of organization. We analysed pupils´ video records and we evaluated influence of various conditions of organization on the quality of obtained video records, i.e. we looked for optimal conditions of organization to achieve our goal of using tablets in laboratory workshops.

The first part of the case study (Chroustová, Machková & Hanzalová) pointed out positive influence of clarifying and detailing the instructions for the work with the tablet (see Table 2) while recording video records of experiments. Clarifying and detailing the instructions led to getting video records of higher quality especially from the technical point of view within both the observed groups (one with previous experience of making video records and the other even without previous experience – see Figure 2).

In the second part of the case study we focused on getting higher quality of video records in their contents. We decided to solve this in connection to teaching ICT – including preparation of the script of planned video records and followed by cutting and modifying raw video records. This showed that including these factors had positive influence on the quality of obtained video records even in their contents as we had presupposed. Thanks to the analysis of video records made by pupils of group B who had prepared their scripts in advance, we found out that making the script helped the pupils to think out the algorithm of the laboratory work including the use of tablets for recording, to organize the scenes better and to accompany them with appropriate comments, although in some cases factual mistakes as well as problems with specific terminology appeared. It is probable that these failures might have been removed by a following consultation of the script with the Chemistry teacher. Connection to ICT lessons also had its positive influence. From the interviews with the teacher and pupils of group B we found out positive impact on the affective part – pupils accepted the task to be their own, they tried to do their best while recording and their motivation to fulfil the task was increased. Worked-out scripts and obtained video records of group B could serve as good feedback about the laboratory workshop for the Chemistry teacher.

Both the parts of the case study show that the chosen adjustment of conditions of organization for the set task (to record a video record of an experiment during a laboratory workshop) leads to pupils´ work of higher quality and to their higher motivation to fulfil the task. Integrating ICT into learning in context with model SAMR (see Figure 1) on higher levels is done not only through changing the task setting and choice of appropriate technology, but also through appropriate adjustment of conditions of organization for the pupils.

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Grade 9 Elementary Students' Conception of (School) Chemistry

Introduction

Students' and teachers' conception along with the conceptual change belong to the most published (we may argue that also focused) areas within chemistry education research (CER) as found out by Teo, Goh, and Yeo (2014). This contribution is in line with this trend as the conception of chemistry education influences broad sphere of related fields from teachers to future scientists. Students' attitudes are considered to be one of the most important aspect in education by many researchers. Contemporary decline of students' interest in Science (Bílek, 2008; Höffer & Svoboda, 2005; Kubiatko, Švandová, Šibor, & Škoda, 2012; K. Salta & Tzougraki, 2004; Veselský & Hrubišková, 2009) has been affecting the numbers of students choosing particular scientific disciplines as their major or, later, career. Different authors mention different reasons, however they all agree the key factor is the course of education, subject matter, methods and organizational forms teachers use when teaching Science or particular disciplines (Biology, Chemistry, Geography, Physics). Another aspect is in relevancy to the students' everyday life (see e.g. Lindner, 2014).

For measuring students' attitudes, questionnaires are the most commonly used. Respondents usually answer on a scale as seen in the PISA (Programme for International Student Assessment) testing or many other researches (see Hassan, 2008; K. Salta & Tzougraki, 2004; Schreiner & Sjøberg, 2005). The second, often used method is the semantic differential (see e.g. Lovelace & Brickman, 2013). Particular pros and cons of the following approaches were discussed e.g. by Schibeci (1982), used e.g. by Brandriet, Xu, Bretz, and Lewis (2011) or Kahveci (2015). The authors of this study, however, are not focused only on attitudes as such, but also at particular aspects of chemistry education. Such a focus demands space for the respondents. Therefore, either interviews or questionnaires with open questions are appropriate.

This study results from a surveys conducted by Rusek (2011, 2013a) on students at the beginning of the first year at upper secondary school (ISCED 3). The author, among others, discussed the quality of chemistry education at elementary (basic) schools (ISCED 2). In the sample, vocational school students were included. This, although appropriately commented, offers only a partial overview as these students are just a part of the student population. Therefore, this study is oriented on grade 9 students who attend either elementary schools or grammar schools. This approach moderates the negative influence of the students' study choice.

Methodology

Goal of the research

The goal of this study was to find out students' attitudes towards chemistry as well as conception of the school subject students leave compulsory education with. The research followed this research question: *What is students' conception of chemistry like before the end of their elementary education?*

Students' attitudes were assessed according to (1) their conception of chemistry as a field, (2) conception of the use of chemistry in everyday life, (3) particular topics the students find interesting and (4) grade the students give to chemistry as a school subject. The students' attitudes at the end of the elementary (compulsory) education mirror the effect of chemistry education on this level.

Assessing overall students' attitude according to the four factors is problematic. It is therefore measured in four different categories according to the particular questions.

Research sample

Altogether 282 grade 9 students (ISCED 2, i.e. 14-15 years old) have been included in the research sample. The students represent both elementary school students (FZŠ a MŠ Červený vrch; ZŠ Sv. Voršily; ZŠ Mnichovo Hradiště, ZŠ Jirkov; ZŠ Velké Popovice; FZŠ prof. O. Chlupa; FZŠ Barrandov; ZŠ Zásmuky) and grammar school students (Křesťanské gymnázium Praha – Hostivař, Městské gymnázium Jirkov). Particular schools were addressed according to prior experience with cooperation with the school. The numbers of particular classrooms included in the survey was adjusted according to the actual proportion of elementary and grammar school student in the grade 9 in the Czech Republic available online in the Statistic year-book[1]. Another criterion of the sample selection was in the size of the city or town each school is located in. The sample represents schools from the capital city as well as schools from middle-sized towns (Jirkov, Mnichovo Hradiště) and small towns (Zásmuky). A size of school was also a criterion. There are big schools (ZŠ Červený vrch, Prague) as well as small schools (ZŠ Zásmuky, ZŠ Velké Popovice) included in the sample. The overall numbers of grammar and elementary school students as well as male (M) and female (F) students are listed in Tab. 1.

1 Available under: http://toiler.uiv.cz/rocenka/rocenka.asp

Table 1. Number of respondents.

Grammar school		Elementary school	
49		233	
M	F	M	F
27	22	111	118

Research tool and its administration

As it was stated in the introduction, the research followed a survey conducted by Rusek (2011); (Rusek, 2013a). The same questionnaire was therefore used. The questionnaire contained three open and one semi-opened question.

- What is Chemistry as a scientific discipline according to you and what does it deal with?
- What is Chemistry good for in ordinary life?
- What captured your interest the most in Chemistry education?
- Mark Chemistry from 1-5 (as in school).

The questionnaires were distributed in March and April 2016. They were administered by teacher students on their one month in-school practice to the school students the research team has a good information about. Overall time for the students to fill the questionnaire in was approximately 20 minutes.

Data analysis

The study uses a mixed research design. The number of participants as well as the sample selection enable to employ quantitative statistical tests on the data. The open-question answers, on the other hand, offer qualitative information.

First, categories used by Rusek (2011, 2013a) were used for particular answer recording. In case a new keyword emerged, it was as a new category. Less numerous categories with similar meaning were eventually merged. Subsequently, the answers in the categories were summarized in order to provide data about occurrence of the particular keywords.

For quantitative calculations, simple formulas in MS Excel were used.

Results and discussion

Conception of chemistry – What is Chemistry as a scientific discipline according to you and what does it deal with?

In the first question, the students' conception of chemistry was assessed. The definition of what is chemistry and what does it deal with is naturally broad. Also it is not reasonable to hold on one definition. That is why certain keywords needed to be chosen. For this, three most common elementary chemistry textbooks were chosen (P. Beneš, Pumpr, & Banýr, 1993, 1999; Škoda & Doulík, 2006). The definitions of chemistry contained the following keywords: natural science, exploring substances, change of substances, study properties and conversion of substances, characteristics of substances. The students' responses are displayed in Fig. 1.

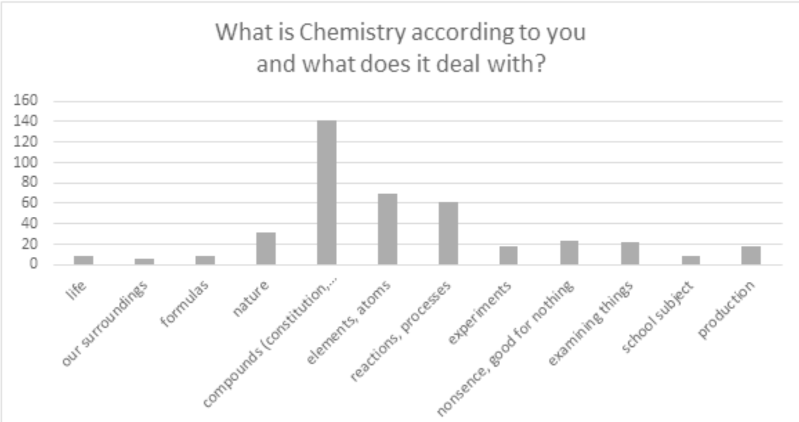

Figure 1. Students' perception of chemistry.

The most commonly mentioned were compounds (their constitution and properties), elements and atoms (structure of matter) and reactions and processes. Particular students' answers were also assessed according to the accordance with the above mentioned text book definitions. The students' who mentioned *three or more* of the above mentioned keywords, were selected as the students who have exact conception of chemistry, the students' who mentioned *two* were selected as the students with general conception of chemistry. Further *one* mentioned keywords is considered no conception. The results are displayed in Fig. 2.

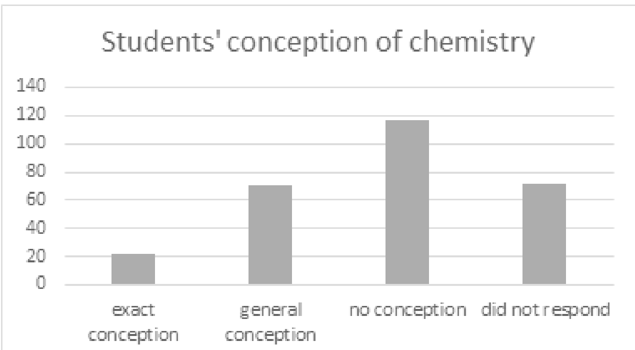

Figure 2. Students` conception of chemistry assessment.

It is obvious that majority of the students do not have a conception of chemistry. More thorough examination of the student answers (quality of the answer when the selected keywords were not mentioned) does not provide significant change. There were several interesting answers noted: “Examinations in forensic laboratory”, “It (chemistry) deals with disclosing the essence of the world via the smallest molecules…” or “It deals with upgrading of chemical procedures, such as conservation”, which suggest the students have a certain imagination. These are, however, seldom. On the contrary, there were several negative formulations. For example, in the answer “When someone says a word to me, I imagine a structure formula. It (chemistry) deals with something I don’t care about and I am bad at it because I don’t understand it”, “I don’t know, I sleep”, or, “I will never use stupid formulas in my life.” Suggest not only extent to which some of the students understand the conception of chemistry, it also suggest what kind of answers may be expected in the following two questions. It is therefore possible to argue that chemistry education at the schools the students attend fails to give appropriate image about the school subject and also the field itself. Nevertheless, to expect students will gain positive attitudes towards a school subject they do not understand as unfounded. The abstract content of a subject causes demotivation (cp. e.g. Katerina Salta & Koulougliotis, 2015; Škoda & Doulík, 2009b).

In case the results were similar on a representative sample and generalization was possible, this would mean a danger for the future of the field. In this case, it would be unreasonable to think the students would choose a field which conception they do not understand as their future field of studies neither their future career (cp. Jorde & Dillon, 2012). Also the idea of *science for all* (see Osborne & Dillon, 2008) fails from the same reason. This idea as well as further aspects of the students’ understanding of the field is further examined by the second two questions. The results, however, also need to be regarded with respect to the age of the students (this naturally applies to all the answers). Some of the negative responses may be mere manifestations of teen-age revolt and may not have anything in common with the students’ actual conception of chemistry.

The use of chemistry in everyday life – What is Chemistry good for in ordinary life?

In contrast to the first question, there is no definition to hold to. This question was, therefore, assessed only in order to find out about the practical aspect which is transferred via chemistry education in the questioned students’ classes.

The answers were mostly brief – one or two words. Their range was therefore broad. The grouping mentioned in the methodological part of this text was therefore necessary. The most numerous category became *practical use*. Some of the students used literally this phrase, whilst some mentioned measuring water eg. “measuring chlorine in the water in a pool”, “hairdressing – I’m going to be trained as a hairdresser so I will need to know how to mix colours”, “sink cleaning substances", one of the most mentioned was cooking. Second the most numerous category was labelled *occupational safety and health*. All the answers leading to safety, mostly based on knowledge of a substance properties e.g. "we know what is dangerous", "I know that I shouldn't drink denaturated spirit", or, "understanding cautionary symbols" have been placed under this category. Third the most numerous was an opinion "good for nothing", "chemistry is nonsense", i.e. category *good for nothing, I don't know*. Fourth the most numerous category was labelled *general view*. It contained responses mentioning general importance of chemistry knowledge in everyday life e.g. "everything we do is a chemistry reaction", "general overview, for crossword puzzles". The counts of particular responses are displayed in Fig. 3.

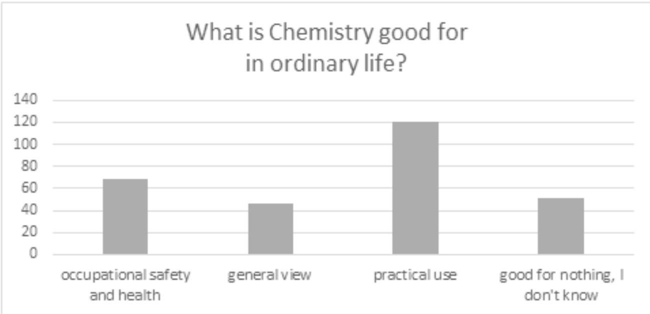

Figure 3 Students' perception of the use of chemistry.

Another not so numerous categories were: *pharmaceuticals and medicine* (35 respondents): "It's important for scientists. They produce a vaccine and a medicine.", *production* (31), *learning about environment* (27), *industry* (19) etc.

As it if obvious from the total counts, the students' responses were not very broad. In the Fig. 4 there are total counts of keywords mentioned by particular students displayed. Having regard to a reduced length of the questionnaire, the

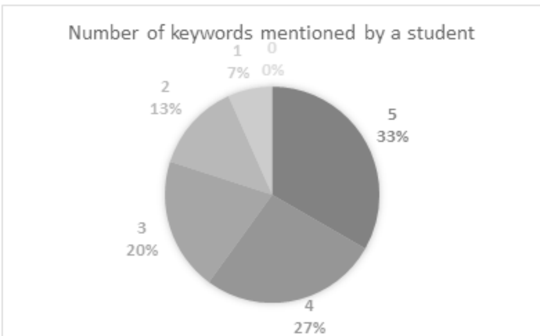

Figure 4 Total count of keywords about the use of chemistry mentioned by particular students.

low count of keywords may be interpreted either as the students' demotivation to answer the question or their inability to think about a school subject in this respect. However, it may also be interpreted as an image the teachers convey these students in chemistry lessons. This would be in line with results of another researches which support the idea of less-popular school subjects considered useless (Rusek, 2013b; Škoda, 2003).

On the other hand, many of the students' responses give the impression there is quite a difference between their view of chemistry as a school subject and chemistry as a scientific field. The school subject, according to some of the students, does not have appealing content, unless the practice is addressed. This is after all a proof of the ideas by e.g. Elkis & Hofstein (2015) or Lindner (2014).

Interesting aspects of chemistry education – What captured your interest the most in Chemistry education?

This question not only inspects on the subject matter students remember from chemistry education, it also offers an insight on motivation towards chemistry. Almost a half of the respondents (129) mentioned experiments as an interesting element in chemistry education. This makes it the most numerous category. This result, however, was expected as this phenomenon is well known from the literature (Pavel Beneš, Rusek, & Kudrna, 2015; Moore, 2001; Škoda & Doulík, 2009a). Nevertheless, in order to work with this information further, closer analysis of the experiments would be necessary. Some examples of unsuccessful experiment appeared, "When a burner exploded and half of the table was on fire." Also answers showing a negative state of chemistry experiment appeared: "If we did experiments, I'd like that. But we don't", "We didn't conduct experiments but we watched them on the internet." Second and third the most numerous categories were covered by 37% of the respondents. The first is not surprising with respect to the time the questionnaires were administered – *hydrocarbons and their derivates* a topic chemistry education is usually focused this time of the year. Nevertheless, popularity of this category may also be caused by its closeness to real life. After a year of inorganic chemistry, which is hard to imagine and chemical formulas become ultimate representation of inorganic compounds, organic compounds are closer t nature – closer to real life.

The second category was labelled *I don't remember, I don't care*. Together with the category *nonsense* (3 respondents) and *boring balancing chemical equations* (2 respondents) they represent more than 40% of negative responses. Correlation between these and the "*good for nothing*" category in the second question (What is chemistry good for in everyday life?) is weak. It is not possible to conclude the students who do not see the use of chemistry in everyday life also do not remember anything from the lessons. Two categories both covered in 6% of answers are on the contrary positive. *I liked everything* e.g. "It's not possible to say what captured my interest the most. All chemistry is interesting for me, despite I sometimes can't manage", or, "I was intrigued by how it is complicated and how everything has some sense". And the second: *practice for everyday life* e.g. "I like when I found out what are things I use regularly made of (PVC)", or, "Learning about the world in more depth." These will be further discussed in the next chapter.

The overall results (see Fig. 5) suggest that chemistry education does not provide the students with knowledge they find interesting. Only seldom did the students mention some specific aspect of chemistry education. Considering the fact students spend around 120 chemistry lessons in the lower secondary school (compulsory), educational results on the affective level are not satisfactory for this sample of students.

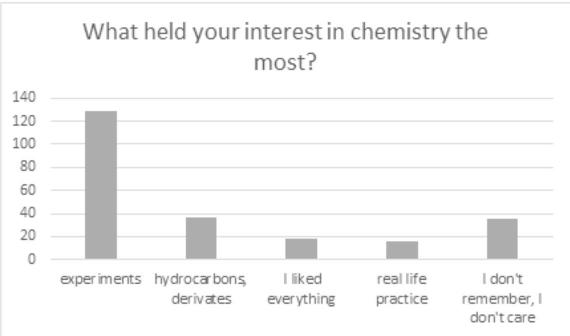

Figure 5. Total count of keywords about the use of chemistry mentioned by particular students.

The Fig. 6 provides information which may be considered either the students' willingness to cooperate via the questionnaire, or a real picture how many aspects

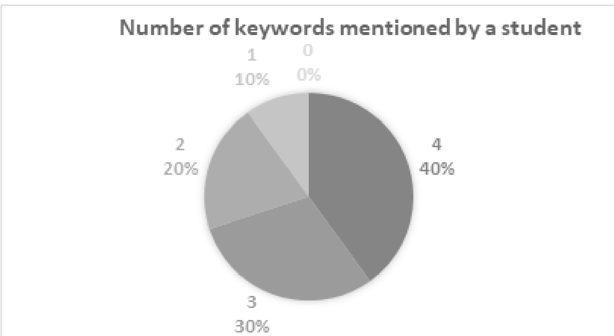

Figure 6. Total count of the keywords about interesting topics in chemistry education by particular students.

of chemistry education they enjoy. It is obvious the overwhelming majority of students mentioned at least one of the interesting aspect. Only 26 respondents did not pay attention to this question or did not think of anything interesting for them.

Mark for school chemistry

In the fourth question, the student's attitude towards chemistry was discovered with the use of school marks (1 being the best and 5 being the worst). In contrast to the other questions, all the students filled this question in. Their answers may also be considered objective because their assessment is not influenced by the final school assessment – the time of the survey was selected carefully. Also, interesting comparison is gained when the students' chemistry school mark from the last half-year is compared to the mark they give to chemistry. The same mark was given to chemistry as a school subject by 37% of the students. Only 16% of the students, grade chemistry better than their mark from the last half-year. This means 54% of the students' grade chemistry worse than their school mark. Correlation between the students' evaluation and their school mark is therefore excluded. The evaluation probably includes the students' attitudes.

The students graded chemistry on average 2,63 (median 2,25). Which is considered to be quite a positive assessment considering the overall results. This value is considerably better that the mean value discovered by Rusek (2011) –

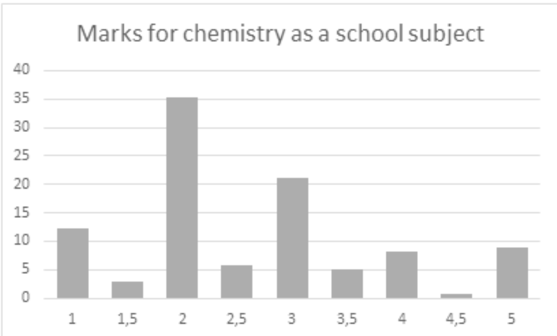

Figure 7. Overview of particular school marks given by the students to chemistry.

3,16. For more detailed information see Fig. 7. It is obvious, the curve is moved to the left making the assessment (school mark) slightly positive.

The students who mentioned that chemistry "is good for nothing" assessed chemistry quite neutrally (mean 3,34, median 3,5). Surprisingly the students who mentioned they liked everything in chemistry education grade chemistry quite unequally (mean 2,22, median 2), with some of them grading 5 or 4. This may be students who did not concentrate on the questionnaire.

Conclusion

The survey contains responses of 282 grade 9 students. It is not possible to generalize the results. However, together with the results of the survey with the similar design (Rusek, 2011) which provided comparable results, some stronger presumptions may be made. The results are in line with the other researches suggesting the students' attitudes towards chemistry (Höffer & Svoboda, 2005; Rusek, 2011, 2013b; Veselský & Hrubišková, 2009). The results in the first three questions imply that chemistry education at these schools fails capture the students' interest despite there are several topics the students find interesting. It seems, school chemistry education does not convey what chemistry as a field really is, what does it deal with, how it serves to the mankind etc. fully so the students would comprehend also the subject matter and its meaning. It is possible to argue the students see (and some of them respect) it as a school subject, the subject matter perceive more as the content of the (artificial) school subject nor like interesting and useful set of information for their life. This might be caused by their teachers' approach, the teachers' teaching attitude and conception of chemistry education.

The single fact the students do not or cannot name more than one (or a single one) interesting topic or even information implies the education is neither practical nor relevant to the students' everyday life. This state matches the, nowadays overcome, scientistic paradigm (see Škoda & Doulík, 2009b) which still persists in Czech schools.

Despite the research sample size does not allow generalization, further information about the state of chemistry education at the selected schools might be gained by employment of sophisticated statistical methods on the data which allow quantitative approach. Particular categories might be assessed based on the type of school the students attend as well as on their gender. The results might also be compared to the results of other authors in more depth. The authors of this survey are going to inspect on the data in this respect in their further contribution.

Acknowledgements

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Identification of the Ways of Using ICT in Chemistry Education

Introduction

Current paradigms of science education, more precisely the process of their creation is not yet finished (Škoda & Doulík, 2009). Science education not only in the Czech Republic struggles with the surpassed scientific paradigm characterised with strong emphasis on theory. It lasts more or less since 1982/1984 (Čtrnáctová & Banýr, 1997) as the majority of nowadays teachers were educated and also trained in this time.

Situation at schools is shrewdly assimilated with the so called Red Queen's Principle/Effect (Allaby, 2004; Van Valen, 1973), i.e. the development is so quick that one (teachers, but also teacher trainers as well as curriculum makers) has to run as fast as one can just to stay in the same place.

This naturally affects children (pupils and students). The differences from the previous student generations are especially in their attitude towards the new technology and also in the value of (memorized) information. Nowadays we speak about the Net generation (Sandars & Morrison, 2007) and Z generation (Homan, 2015), from the science education perspective see also Papáček (2010). Their characteristics with respect to the use of ICT as well as the way of cooperation are well described. Unfortunately, the position of school (education) is not adapting as needed, the process of teacher training resists as well – see the Horizon Report (Johnson et al., 2015, p. 28).

According to the analysis results by Teo et al. (2014) chemistry education research (CER) nowadays focuses mostly on four spheres. They are:

- learning – students' and teachers' conception and conceptual change,
- teaching,
- learning – classroom context and learning characteristics,
- goals and policy, curriculum, evaluation and assessment (Teo et al., 2014, p. 473).

These topics are the most focused on in science or chemistry education research oriented journal papers (over 100 from 2004–2013 according to Teo et al. (2014)). Together with these, educational technology, mostly the use of information and communication technology (ICT) is an abundantly published topic. It is obvious, these topics represent attempts for innovation of education. Despite modern approaches are often a mere comeback of a method, ICT brings new opportunities and also challenges (see Taylor, 1980 – computer as a tutor, tutee, tool or a toy).

This work represents a step forward in the traditional conception of innovation. Innovation, in many books and papers, is used as a synonym for technology. This may be applied in business, in education, however, the Taylor's (1980) structure clearly defines the possible use of technology. The era when any use of ICT in education was considered innovative is over. Attention is being focused on effectiveness of the use of ICT.

Natural use of ICT in education (in-school, i.e. formal education) also corresponds to another big issue of contemporary educational approaches – relevance of the subject matter or the school topics (Lindner, 2014; Van Aalsvoort, 2004). A very common students' question "Why do I have to learn this?" affects their motivation, hence willingness to study (see e.g. Rusek, 2013). This is a vital factor as the progressive educational approaches applied nowadays in science education – inquiry-based or project-based education – are built on students' motivation to engage in an activity themselves.

Methodology

The authors of this volume decided to focus on (1) finding how and by whom are modern technologies used in chemistry education at secondary schools, (2) what teachers consider innovative in education and (3) innovative teaching methods or forms. A qualitative research (interviews with pre-selected chemistry teachers) was carried out in order to answer the questions.

Goal of the research

The goals of the research from the 1–3 points above were concretised in the following three:

1. to identify the perception of the concepts of innovation as well as educational forms and methods that are regarded by teachers as innovative,
2. to establish the correlation between teachers' attitudes towards innovation and the various options for the use of ICT in chemistry education,
3. to validate the results of the first part of the survey (teachers' attitude towards the use of ICT in chemistry education measured by a questionnaire).

These goals were transferred into the following research questions:

1. What innovative concepts, educational forms and methods do chemistry teachers consider innovative?

As often encountered in practice, teachers use various educational forms and methods intuitively. They do not need to name them or classify them. In case a teacher does not develop their education further, after some time he or she loses not only an overview of current trends in education, but also their ability to understand them. From this reason a questionnaire survey (often – incorrectly – used for researching this field) does not provide reliable information. Only the methods which enable a researcher opportunity to ask further may bring required information. Also, innovation is often regarded differently by various teachers. For example Stárková and Rusek (2015a) surveyed on prospective teachers' attitude and conception of innovation. The results confirm a possibility to find some trends or patterns of attitude towards science as defined by Rogers (2003) and verified in the Czech conditions e.g. by Zounek and Sebera (2005).

In order to enhance the process of diffusion of innovation, first the innovative teachers must logically be identified. This, later, enables to create methodical support which is in compliance with teachers' needs.

2. How does a teacher's attitude towards innovation affect their use of ICT in chemistry education?

Interview as a method enables to ask further questions about the real school practice. The authors of the research are aware of the fact that lesson observation and student questioning (questionnaire or interviews) in triangulation with the teacher questionnaire would be more suitable. Nevertheless, when focusing on innovative aspects, every lesson cannot be expected to contain them. Greater volume of the lessons would have to be observed which would again increase the time consumption (cp. Disman, 2005, p. 141). Teachers' description of the innovation completed with their further explanations when needed will also be sufficient.

3. To what extent do the results of the questionnaire survey match the results gained via interview?

Validity of information gained by an interview is considered higher that validity of questionnaire results. On the other hand, the number of interviewees is limited because of the method's time consumption (Disman, 2005). The style of interviewee selection is also at stake. From this reason is this research built first on the results of a questionnaire survey.

First, the authors of this research selected particular groups of chemistry teachers according to their attitude towards innovation in education. They used a questionnaire based on the Roger's theory of diffusion of innovation (Rogers, 2003) created by Kankaanrinta (2000). The questionnaire was translated to Czech and used by Černochová et al. (2001) and Zounek and Sebera (2005), further adapted for the condition of chemistry teaching by Stárková and Rusek (2015a).

Teachers divided in the five Rogers' (2003) categories: innovators, early adopters, early majority, late majority and laggards are possible to be characterised according to their attitudes towards innovation, the use of innovations, role (influence) in the society etc. Since this research is focused on the teachers' perception of innovation in the educational process, it is reasonable to think teachers who feature distant attitude towards novelties are not suitable respondents. Moreover, focusing on innovative teachers (mostly innovators and early adopters) brings the advantage of enhanced impact on the entire teacher population once larger cooperation is established.

Results of each of the interviews were compared to the teachers' questionnaire results. By doing so the validity of the instrument was being confirmed.

All three research questions have a descriptive character, therefore no hypotheses were formulated (Gavora, 2000). The qualitative conception of the research is also in line with this approach.

Research sample

Preliminary use of the questionnaire survey results in order to sort the suitable interview candidates before the interviews seems reasonable. As mentioned before, this volume describes only a part of a complex research. The first part was quantitative, all secondary schools in the Czech Republic with adequate number of science lessons prescribed by the framework educational programme (7 and more lessons per week) were addressed with an electronic questionnaire as only at these schools is chemistry being taught in sufficient depth (see Rusek, 2013). Therefore, only grammar school and some vocational school teachers were included in the questionnaire survey. Also only the teachers identified as innovators and early adopters were included in the prospective-respondent pool.

Considering the time consumption of interviews, the travel time was limited by choosing only teachers from Prague and the Central-Bohemian region. Further information about the respondents are listed in the Table 1. It is notable, that interviewed teachers differ also in quantity of chemistry lessons they teach, combination with another taught school subject and other activities (e.g. leading of projects) which affect their potential contribution to the research. An ideal respondent is a teacher with at least 10 chemistry lessons taught weekly.

Table 1. Information about the respondents.

	1	2	3	4	5
Sex	M	F	F	F	F
Type of school	grammar school	vocational school	vocational school	grammar school	grammar school
Years of practice	4-10 years	31-40 years	21-30 years	4-10 years	11-20 years
Degree of education	doctor	magister	doctor	magister	magister
Type of university education	science	pedagogy	science	pedagogy	Pedagogy

Data analysis

This text is focused on the qualitative part of the research only. The interviews were transcribed and further analysed according the key words identified in the teachers' answers to the particular questions.

Results and discussion

The results of particular teachers will be held separately. The first part of the interview was led by the first research question (What innovative concepts, educational forms and methods do chemistry teachers consider innovative?). The teachers were asked about their perception of innovation so their opinion could be matched to the conceptions from the literature.

Innovative forms and methods

The first of the teachers supported improvement of education in any way. He claimed students' learning styles does not necessarily need to be changed, neither educational methods. Here, however, proved his lack of erudition in the next sentence when he said a change in approach is needed. When describing innovative educational method he was quite general. A different teaching style than classic frontal teaching is considered as innovative. He then, mentioned greater student involvement, which corresponds with stimulating students' curiosity.

When we focus on the meaning of the teacher's message only, his view of innovation is in line with student-centered approaches (see Baeten et al., 2016; Granger et al., 2012) and student activation in general (Gabriel & Rusek, 2014; Janštová & Rusek, 2015; Salta & Koulougliotis, 2015).

The second of the interviewed teachers considered interesting education as the main innovative element. She mentioned that the students should be impressed by a school subject or the field, for example through connection with practice (universities, factories). This opinion is in line with several researches among others Olsen and Lie (2011) or Krapp and Prenzel (2011). This teacher also stressed the importance to teach the students to think logically, predict some things – "that sort of analysis and synthesis". (see e.g. Bayram & Comek, 2009; Jasečková & Krivoňáková, 2016). A cooperative learning with elements of research (to form students' idea) was considered innovative.

An interesting remark was made on meaningful use of ICT. The teacher expressed her awareness of overwhelming influence of ICT on everyday life, at the same time she stressed its reasonable use, for example in computer-aided experiments (labs with Vernier). This problematic has been discussed by many authors, i.a. (Ariza & Armenteros, 2014; Guedens et al., 2012; Stárková & Rusek, 2014, 2015a, b). A model designed by Taylor (1980) has fittingly offered a theoretical anchorage which remains until the contemporary state of the use of ICT in education. It is notable, that this teacher refused e-learning as suitable for Chemistry (maybe for enumeration equations, reactions mechanisms and verification of knowledge). This is nevertheless just a small part of Learning Management Systems' capabilities.

The third teacher considered trying out new things as innovative. She is willing to risk making a fault before her students. When something unexpected happens (usually some technology failure), students are trying to help her (they are more adept). According to this teacher, it is also important not to be afraid to say: "I can't do this." Admitting this imperfection makes her more human for students. Close relationship to students is for her very important, that is why she is trying things her students usually do, e.g. playing computer games, so she can discuss it with the students. Eventually, the teacher also mentioned that common problem solving and avoiding stereotypes are very important. Innovation should not be blind, but in order to bring added value.

According to the fourth teacher, innovation is anything that a man brings and is not rigid and usual. This perception is quite general and teacher-oriented. Then she added an example of her own practice – conducting an experiment is innovative for her students, because they are not accustomed to it. This teacher's innovativeness is questionable in this respect. She mentioned the absence of students' experiments because of the absence of laboratories and lab equipment. This collides with the resourcefulness of innovators or early adopters as described by Rogers (2003). For example in a paper by Beneš et al. (2015) the authors discuss several options how to support school education experiment in conditions similar to the ones described by this teacher. Nevertheless, she followed on answering the first question and mentioned realization, invention and documentation of an experiment (video working) and inquiry based education as innovative approaches.

The fifth teacher was very pesimistic about innovations. At the beginning she declared, that there is nothing that can be innovated in education. After a while she mentioned the involvement of new media (internet, tablets etc., because these technologies are part of everyday life) and group work. By the teacher with this attitude, a very conservative educational approach might be expected.

Nevertheless, as it turned out, this teacher is very open to innovations in general. She uses a classroom equipped with tablets and adapts the education to her students' needs. The reason for the contradiction between this and her initial statement lies in the perception and understanding of the term innovation. As an innovative educational method she mentioned inquiry-based education. On the other hand, project-based education is according to her not innovative at all. From this respect, a set of questions or statements based on general attitudes to situations from practice which help to deduce a teachers' innovativeness may serve well enough when the word *innovativeness* is omitted.

Innovations in chemistry education practice

Teachers' awareness of innovative methods, forms and approaches in education gives a certain overview. However, the real practice is more important. The second research question (How does a teacher's attitude towards innovation affect their use of ICT in chemistry education?) was answered as a link with the first question and the following question (nr. 2) the teachers were asked: How do a teacher and his students use technologies in Chemistry education?

From the perspective of the research question, the first teachers' attitude towards innovation is mirrored in various applications of ICT in his in-classroom practice. He mentioned the use of projectors (for presentations) and school measuring systems (for visualisation). His students use the measuring systems too because of the closeness to professional equipment. By this remark the teacher explained his conception of the goal of chemistry education – preparing for the profession (cp. e.g. Jorde & Dillon, 2012, pp. 5–8). Despite this approach is considered overcame by some authors such as Osborne and Dillon (2008), the emphasis on practical chemistry is important. The use of experiments is a vital feature of a good chemistry lesson necessary for developing scientific skills (Beneš et al., 2015; Škoda & Doulík, 2009).

The teacher also mentioned use of interactive periodic tables and ChemSketch by himself as well as his students. However, Learning Management System (LMS) was mentioned as an unused application. By doing so the teacher expressed his specific vision of "e-supported" chemistry education. The use of interactive apps further reflects the level of this teacher's innovativeness. The apps running on mobile devices became an issue of modern education within the m-learning movement (e.g. Stárková & Rusek, 2015b; Suki et al., 2006).

The second teacher mentioned films and experiments screening as usual usage of technology in her conception of chemistry education. Despite there are lots of videos on YouTube, the discussion about the suitability of video-experiment is still actual (Škoda & Doulík, 2009).

Within this question, the teacher also mentioned her approach to student motivation or activation. According to her a good teacher should constantly responds to how his/her students face and if they are pleased, i.e. constantly reflect students' needs. According to them it is possible to make little steps to increase their interest.

When asked directly for the example of ICT use in her chemistry lessons she mentioned her students use their own ICT mostly for searching for information. This may be considered a link between everyday life – using one's own device to look for information – and school instruction. However, in the respect of ICT use in education, this teacher's responses did not confirm her innovativeness.

The third teacher, on the contrary, may be considered an example of the ICT-using teacher. She mentioned conducting demonstrative experiments with laboratory set Vernier, search for and use online videos. This teacher was the only one who mentioned online storage (One Drive) used both by teacher and students for making and turning in lab protocols and graduation projects. By doing so she promotes the students' information literacy as well. The school of this teachers uses a LMS, but the teacher does not use it. She claims there are not such tasks in Chemistry, which could be turned in. This is probably caused only by the choice to use cloud disposal site instead of the LMS environment.

The students of this teacher are also encouraged to use digital textbooks and notebooks (for making notes and photo-documentation of their chemistry lessons).

An interesting aspect of this teacher's approach towards mobile technology, namely smartphones, was also mentioned. The students can use their devices, but only with supervision of the teacher. This represents an effective approach towards the use of m-learning often criticized for its distracting effect (Katz-Sidlow et al., 2012; Stárková & Rusek, 2014).

The fourth teacher mentioned that she uses projector (for presentations), sometimes interactive whiteboard. From the lab equipment she has only pH meter, so she makes easy experiments with it. Similarly to the other teachers, she mentioned the use of videos and animations. Interestingly she mentioned VHS in this respect followed by YouTube. Further, she mentioned ChemSketch which she uses to show the structure of molecules and chemical equipment to students. This implies there is also lack of equipment at her school.

This teacher supports the bring-your-own-technology BYOD movement (when appropriate), e.g. for testing in the form of QR codes and searching for information. Editor ChemSketch is used by students at home, they can use it in presentations and lab reports.

The last, fifth teacher, mentioned making a lot of worksheets and presentations. Her school is equipped by not only computer, but also tablet classroom, so she takes students there. Student usually work with applications for practising the nomenclature of the elements, searching for and processing information, measurement and making presentations. This teacher is the only one who mentioned her students use special mobile apps oriented on Chemistry . Her students cannot use their own devices because of the school rule. As a LMS eKabinet is used both by teacher and students.

Comparison of the questionnaire results with the interviews

Last third research question (*To what extent do the results of the questionnaire survey match the results gained via interview?*) was oriented on validation of the questionnaire. In order to check the validity of the instrument, four items about innovation from the questionnaire were picked, reversed into questions and asked during the interviews. The results have already been included in the passages above. The overall result, however, is, during the interviews the respondents were more restrained than in the questionnaire. Nevertheless, when asked for more details, the responses were in line with the questionnaires, more importantly with the descriptions of innovators' and early adopters' characteristics.

Conclusion

This qualitative research showed several differences in secondary school chemistry teachers' conception of innovation. Even when the teachers have equal (or similar) attitudes towards innovations and the usage of ICT in chemistry education according to questionnaires, great differences between their perceptions of in-classroom innovation and attitudes towards innovation are discovered when using an interview as a research method. This acknowledgement is very important, because it raises the task of understanding modern education mentioned terms by the teachers.

As in the other texts, the interviewed teachers unanimously mention ICT as innovation in education. Further, they perceive activating methods headed by chemistry school experiment as innovative. The teachers mostly proved their innovativeness by using m-technology, working with a cloud disposal sites or LMS as well as measuring systems promoting school experiments. It is also possible to conclude the questionnaire by Kankaanrinta (2000) adapted for innovation in chemistry education by Stárková and Rusek (2015a) provides valid information and is a suitable tool for general respondent categorization according to their innovativeness.

Despite the interviewed teachers are innovative according to a questionnaire survey results, they have different ways of using ICT in chemistry education. They are limited not only by their experience (e.g. with the proper project based education), but also by school devices (e.g. videos cannot be played in classrooms) or school conditions and regulations (BYOD, the use of personal devices at school etc.). Even between the same level of education differences in equipment (e.g. by Vernier sensors fully equipped science school laboratory vs. non-existent lab) were discovered. Inquiry-based education as often mentioned innovative method could not be therefore developed on the same level.

There was one common issue among the respondents – the lack of time. Time to work innovatively, to work with ICT, to do projects, to do experiments etc. with a lot of content. This is of course a very serious problem. Innovations should raise from the teacher, who has to be motivated to think and act differently. Teacher training and cooperation with universities seems logical in this respect, however a change of curriculum seems to be vital.

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Selected Methods and Forms of Management and Organisation of the Chemistry Learning Process

Introduction

From 1999, chemistry begins in Polish schools in the third stage of education, in the first grade of lower secondary education, which corresponds to students aged 13 years. From September 2017, after the introduction of the reform of education, science begins in the 7th grade of primary school, i.e. at the age of 13, or at the age of 12 in the case of children who started school education at the age of six.

Although formally, pupils of the age 13 should already be able to start thinking abstractly (Nodzyńska, 2002), however, many pupils find this new subject difficult and it is widely regarded by pupils as difficult (Paśko & Baprowska, 2008). Difficulties in learning result primarily from the specificity of the subject, but may also be caused by improper organisation of the learning process. Appropriate scheduling of learning time is a skill that can be and should be used by learners however it seems to be the big problems for teachers too. The systematic acquisition and deepening of chemical knowledge depends not only on the teacher's attitude, but above all on the learner.

Organisational Forms in Teaching Chemistry

Teaching is a long-lasting, systematic, planned and direct process of managing learning; control plays an important role in it. During the lesson a teacher directs the students 'work: defines the tasks to be carried out and the time needed for it, then controls the pupils' work, rewards them for good work or corrects mistakes that students made. The teacher organises work during the lesson: he prepares the necessary teaching aids and materials, selects the methods of work appropriate to the age and possibilities of learners.

The effectiveness of teaching is determined not only by teaching methods, but also by organisational forms used by teachers. The selection of forms of teaching organisation depends on many factors: the place of teaching, the number of students in the classroom, the access to teaching aids as well as the specificity of the subject. The construction of a lesson changes depending on the needs of teaching and various other circumstances, as well as on the interests of students. If the lessons are carried out consistently, in the same way they are boring for students (Półturzycki, 1985).

There are several ways to classify organisational forms:

- regarding to the number of pupils, we can talk about individual or collective teaching and also about individualised, cooperative, collaborative, group, team and next other specialised form of teaching;
- regarding to the place: class lesson, lab lesson, out of school lesson (homework, museum, science centres etc.), extracurricular lessons,
- regarding to the student's working time: one hour class-lesson, two hours class-lesson, whole day activities, long-time activity, month activity, half-year, semester, trimester etc. (modified by Kupisiewicz, 2000).

The oldest organisational form of teaching is individual teaching. The advantage of such work with a student is the ability to adjust the pace and content of teaching to the needs of a particular student. It is effective, but for economic reasons rarely used. Collective education to which the class-lesson system belongs is most often used. Students are gathered in similar age groups, where teaching is carried out in accordance with the designated annual plan. The organizational unit in this system is a lesson (Kupisiewicz, 2000).

A lesson is an organisational form of teaching, based on the implementation of a particular didactic task within a set time. It is considered to be the basic form of teaching and learning through which the education process takes place. The structure of the lesson depends on many factors, first of all from the adopted goals, didactic tasks, age of students and the methods and means of teaching used (Okoń, 2004).

How is a typical chemistry lesson going? In Polish schools it has been established that the lesson consists generally of 8 parts:

1. Welcome.
2. Checking presence.
3. Checking homework / asking students for the last lessons.
4. Reference to the topic.
5. Providing a topic.
6. Realisation of the topic.
7. Lesson summary, lesson synthesis. Applying the knowledge and skills gained in relation to other messages of culture and other fields of art; fixation.
8. Task and explanation of homework (homework should not exceed the possibility of a pupil).

Depending on the content, methods and didactic means planned for the lesson, we distinguish the following types of lessons (Półturzycki, 1999): transmitting, introducing, problem based, exposing, practicing, fixing, checking etc.

The problem lesson leads to the solution of the perceived problem, the children learn to formulate goals, hypotheses and conclusions. The teacher's task is to direct the problematic situation and the students task is to recall their knowledge and use it to identify the problem. The next step is to verify the hypothesis and attempt to find solutions to the problem. This stage is the most creative, because the student must propose solutions by himself. In this way, the resulting hypothesis is subjected to a theoretical or empirical check depending on the problem. Thinking about thinking (critical, logical, analytical, innovative) in the opinion of collectivists should become a priority in every subject education.

At the transmitting form of a chemistry lesson a teacher gives students knowledge in an orderly manner and makes it easier to remember (for example, difficult chemical concepts). However, this way of teaching is not considered by many authors as conducive to learning.

The main task of the exposing lessons is to develop the imagination and to evoke emotions, create a product and then discuss its results and discussion. This type of lesson can be realised throughout implementing the project method. Education is then based on the constructivist ideas of self-creating of knowledge. Student development thanks to new technologies can take place anywhere and at any time, learning becomes more individualised. The teacher is an adviser and moderator of students' own development.

Training (practicing) lesson. In general, students perform specific activities that are repeated in order to develop appropriate skills (practical skills important in laboratory work or the ability to solve chemical tasks). There is one more difficult task before the chemistry teacher: a chemical experiment should be introduced into the lesson process. Experiments should be realised in the classroom, however, if there is no possibility to conduct an experiment in the classroom, the teacher can take advantage of a wide range of films presenting it. Performing or watching an experiment motivates students to work and influences their interest in the lesson (Bernard, Broś, and Poźniczek 2006).

The introductory lesson is to arouse interest and develop a positive motivation of the student, which favours learning.

The specificity of the subject, which is chemistry, requires constant recording of the acquired information, because most of them constitute a "basis" to understand more difficult teaching content. Therefore, thanks to the checking/evaluating lesson the knowledge of the pupils' knowledge, allows the teacher to organise further classes so that the learning goals are achieved. In other words, the results of such knowledge checking should be used for evaluation purposes.

Time management of students' work during a chemistry lesson

Educational processes should be organised in a way that is conducive to learning. Students should know their goals and requirements and participate in the learning process and skilfully plan the time of learning so that it is the most effective. The teacher organises students work on lessons, determines the time to perform specific tasks, supports the student, by transferring knowledge about how to learn, helps in planning and organising the learning process, provides feedback and motivates.

The way of time management and forms of work during the lesson determine the effectiveness of teaching. "The teacher should include in his work plan diagnoses of students' work, develop them on their own and correct their work plan on their basis" (Pawelski, 2005).

Learning outcomes are important not only for students and teachers, but also for school heads, governing bodies, and representatives of the pedagogical supervision authority at the voivodship level. These outcomes are subjects of various analyses and comparisons. Symposia, debates and conferences are organised, and conclusions from them should be implemented to educational process as quickly as possible.

Bearing in mind the above-mentioned aspects of planning of didactic process, research has been carried out to check how the chemistry learning process is organised.

The Research

The research concerned the course of chemistry lessons in lower secondary education. The aim of the research was to find the answers to the following questions:

1. Are the chemistry lessons interesting?
2. What is the way the chemistry lessons the most often take place?
3. Does the teacher help pupils in the planning and organisation of learning in frames of chemistry lesson?

In order to find answers to those questions the survey was used. The research was carried out on a group of 830 students attending chemistry classes in one of 13 examined lower secondary schools belonging to one of the districts in the Śląskie Voivode-ship (in the further graphs they are marked by letters A – M).

Findings

The analysis of the results of the research can start with open question: What is the way the chemistry lessons the most often take place? Among the lower secondary school surveyed students, more than 90 % answered that chemistry lessons are conducted in a manner typical for other lessons. The lesson usually (90 % of answers) begins with checking the pupils' attendance and presenting the subject of the lesson. The teacher then leads the lesson using the most common transmitting method and sometimes after that the lesson just ends, 38 % of students wrote that then the students do exercises, 50% of the students said that at the end the teacher repeats the most important information from the lesson or asks students what they remembered and presents the tasks to do as a homework.

Repeatedly repeating the same lesson scheme may cause monotony in the students' feelings (see fig. 1.). Monotony can lead to boredom and discouragement of the subject.

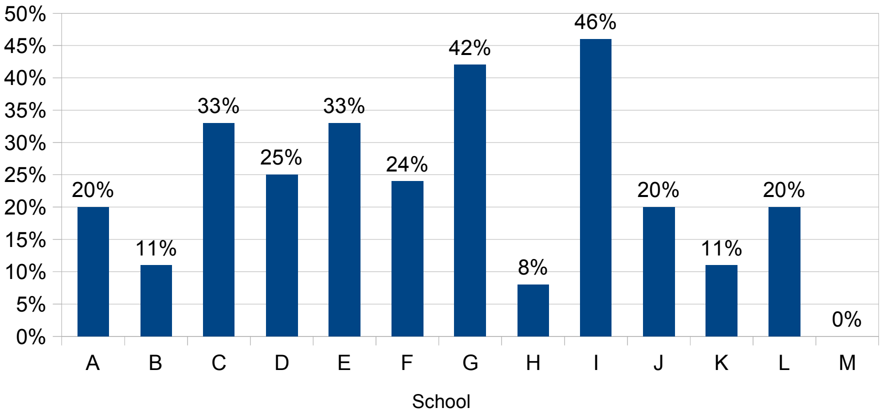

Figure. 1. Percentage of students tested in individual schools who found that chemistry lessons are monotonous.

The figure 1 shows that the level of students claiming that chemistry lessons are monotonous in individual schools is very different. However, up to 9 schools, out of 13 participating in research, the level of monotony is higher or equal to 20%.

Monotony during lessons leads to boredom, what is shown in the graph below (fig. 2). The boredom experienced by students in chemistry lessons is undoubtedly influenced by the monotony of lessons being taught. In 7 schools, the level of 'boredom' in the class is higher than the level of 'monotony', in 4 schools the level is the same, and only in two schools despite the fact that lessons are considered monotonous by some students - less pupils find the same lessons boring.

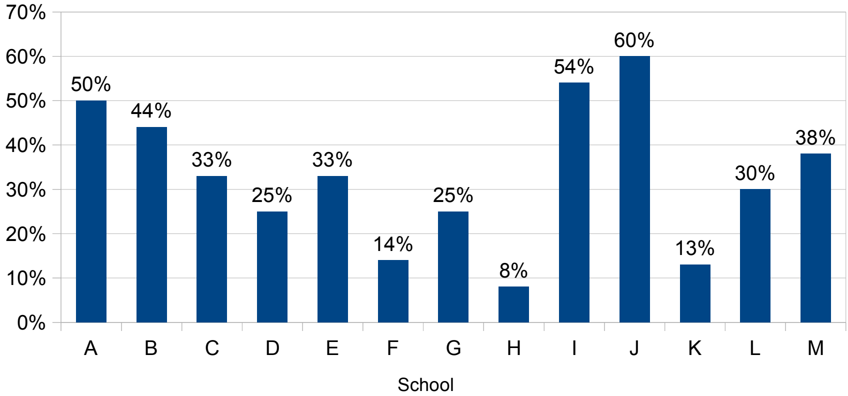

Figure 2. Percentage of students tested in individual schools who found that chemistry lessons are boring.

Therefore, it can be concluded that the plan of the lessons, identical in each case, the identical order of the elements of the lesson causes the pupils to feel monotony, which in turn contributes to boring chemistry lessons. In the researched schools, the lessons are usually mixed: the teacher explains the problem, conducts and discusses the experiment and then the students solve tasks. There are almost no lessons during which students solve problems by themselves (Tab.1). However, students do not think that it is a good way to learn.

Analysing the relationship between monotony and boredom in H and K schools, it can be said that if the lessons are quite varied and not felt as monotonous, then students will not be bored in such lessons. In addition, in these two schools very often teachers conduct experimental lessons, and less often other types. At school J, despite the fact that the lessons are not conducted in a monotonous manner, students are bored. It can therefore be concluded that the causes of boring lessons will be different in this case. Perhaps because the teachers in the school put the emphasis on mastering theoretical issues, giving up typically experimental lessons (Tab.1).

Another worrying phenomenon is the fact that not all teachers have enough time for such an important element of the lesson that is summary of the lesson. In as many as six schools, over 50% of students say that teachers do not repeat the most important information. Teachers in these schools do not pay attention to the most important content and skills that should be mastered by students (Fig.3).

Another circumstances that may indicate that teachers plan lessons improperly and organise the time is the fact that they do not ask students whether any part of learning content requires re-explaining (Fig. 4) and they do not check what the pupils remembered (Fig. 5).

Table 1. The results of pupils' answers the question: What types of chemistry lessons you think are the most frequent in your school?

	Introducing new theoretical concepts (the teacher explains difficult concepts).	The teacher gives the task, the problem to be solved, and the students work to solve it by themselves.	The lessons are mixed: the teacher explains a little, performs the experiment, the students solve the tasks.	Pupils do experiments throughout the lesson and discuss them.	Repetition lessons - preparation for tests
A	80%	8%	2%	10%	0%
B	45%	0%	0%	55%	0%
C	80%	0%	0%	20%	0%
D	77%	2%	10%	11%	0%
E	78%	0%	0%	22%	0%
F	63%	1%	1%	35%	0%
G	40%	3%	1%	56%	0%
H	10%	2%	8%	80%	0%
I	50%	0%	2%	48%	0%
J	68%	0%	0%	32%	0%
K	20%	0%	5%	75%	0%
L	44%	0%	0%	56%	0%
M	45%	0%	10%	45%	0%

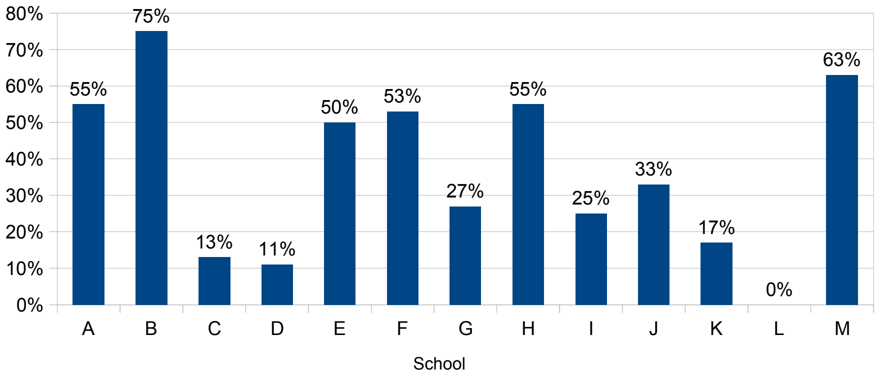

Figure 3. Teachers' activities in the final phase of the lesson (1).

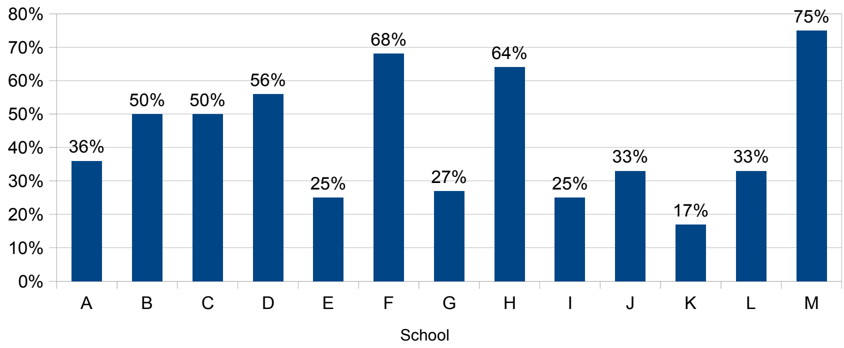

Figure 4. Teachers' activities in the final phase of the lesson (2).

If the teachers do not check whether students understood and assimilated the learning content, as it took place in schools (schools K, I, E, G), then they can't react immediately and re-explain the content incomprehensible for the students. Students' difficulties will therefore increase, and the teacher probably will learn about them much later for example as a result of the test.

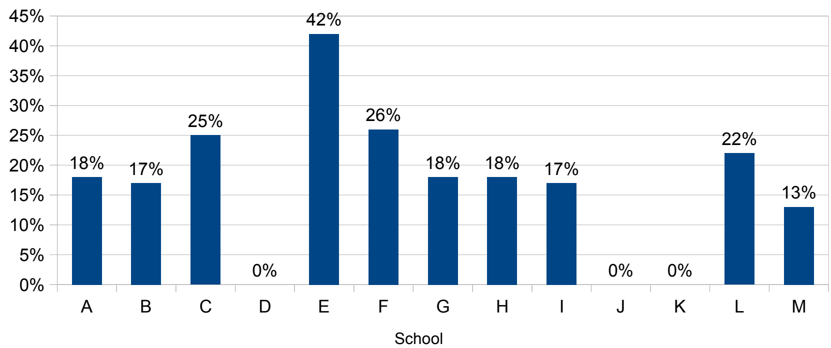

Figure 5. Teachers' activities in the final phase of the lesson (3).

In schools D, J, K the teachers do not ask students what they remembered from the lesson, thus not giving them the opportunity to repeat and consolidate new issues (Fig. 5).

Teachers have a problem with planning the time of the lesson, in consequence, there is lack of time for all phases of the lesson. What's more, teachers do not teach students how they should plan their study time and do not set long enough time framework for pupils to do ordered tasks (Fig. 6, 7).

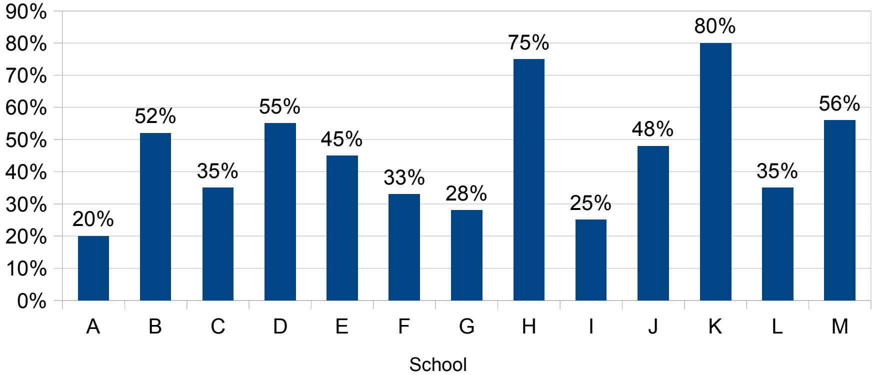

Figure 6. Answers to the question if the teacher strictly determines the time in which a task is to be performed?

As it was revealed in Fig. 2 in H and K schools, lessons for students were not boring. It can be combined with the fact that if a teacher strictly determines the time in which a task is to be performed and it is the time appropriate for a given activity (not too long) then students are not bored when they do their job. Moreover, they also do not waste the time on unnecessary conversations with colleagues - so they are more disciplined and focused on the lesson.

In other schools, either the time to perform a task by the students is not strictly determined which may cause finding this lesson boring (as in the case of school J) or lack of focusing on lesson can be seen in the case when teachers give students too much time for performing the tasks. In addition, it would seem that too long time to perform tasks may, among others, result in lack of time at the end of the lesson for such important activities as: checking the level of understanding of difficult knowledge and summarising the lesson. However, it is not possible in all schools to see such a relationship by comparing the figures 3-6. Perhaps the lack of a summarising phase during the lesson results from the fact that teachers do not think that it is important enough to schedule time for it? This is a question that requires further research.

Figures 8 and 9 reveal that teachers do not help students plan their studies almost at all and they rarely suggest the ways how to learn chemistry (Fig.8, 9)

The Fig. 9 shows that chemistry teachers in the studied schools do not advise students how to learn specific content from a given lesson, but in several schools (E, F, H, K) teachers mentioned the principles of effective learning.

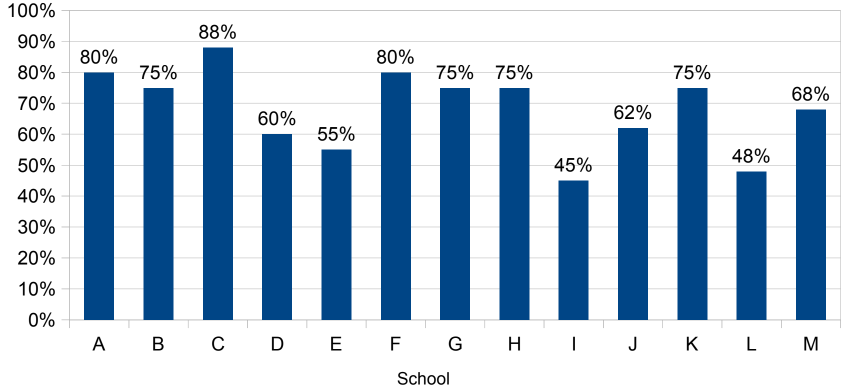

Figure 7. The studests' answers to the questions if they have enough time for the activities that the teacher planned for them.

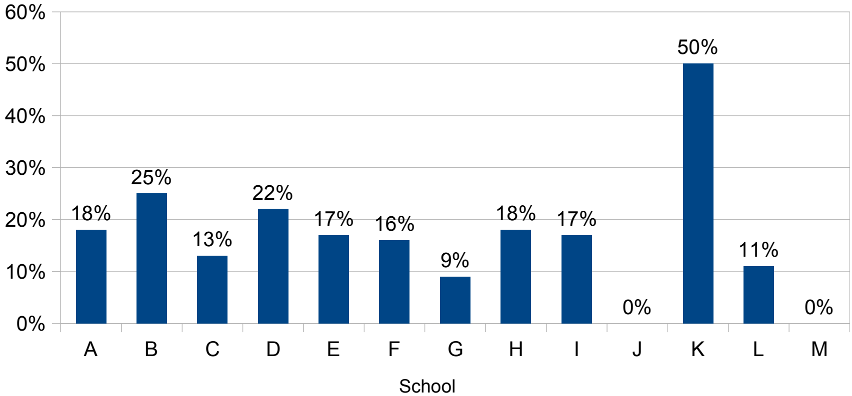

Figure 8.Do teachers tell students how to learn? The teacher tells us how to learn a new material.

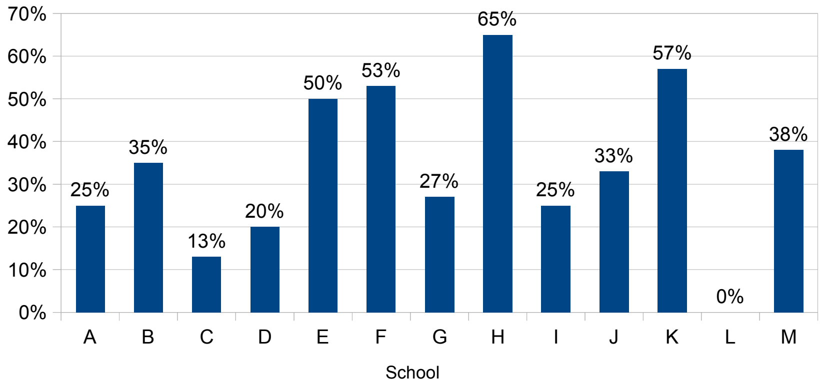

Figure 9. Do teachers tell students how to learn? The teacher told me how to learn effectively.

Conclusions

The analysis of the conducted research shows that in a few of the studied schools the lessons are not very attractive and not well scheduled. Teachers spend too much time on the initial actions of the lesson so many of them do not have time to summarise the lesson, check if the students have understood everything. There is also a lack of time to help the student to organise an individual studying at home. This may be due to improper organisation and time management.

Regardless of the type of lesson, the majority of chemistry lessons in the schools studied are in the same way. This situation is not correct. The lesson structure and the time devoted to its individual elements in the examined schools should be decidedly different.

Acknowledgement

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Using Computer Models to Teach Organic Chemistry at the Chosen School in the Russian Federation

Introduction

Technology is an everyday part of our life and it also found its way to the educational process at all educational levels and in different subjects, in both humanistic and scientific fields, the technology assists the teacher with a graphic presentation of the curriculum. Its inclusion in education gives students an opportunity for more efficient curriculum learning. Undoubtedly, the computer models may be included to the technology. They are perceived as a didactic tool which is beneficial to both teacher and students in the educational process.

The article presents a pedagogical experiment which was conducted in a real school environment. Therefore, it was a natural (field) pedagogical quasi-experiment which enabled the collection of the necessary data (Gavora, 2000).

The application of our constructed computer models represented the dependent variable. The experiment was conducted in the Russian Federation, particularly at a Gymnasium 1 grammar school in Penza in order to determine the contribution of computer models in organic chemistry teaching. The experiment was carried out in two classes of the grammar school within an organic chemistry theme part - amino acids, which are ranked among the most interesting topics for students.

From the chemical point of view, the amino acids are building units of all the living organisms. The molecular models created using computer software PC Spartan Pro (Spartan Pro, 1999) were used for the demonstration of amino-acids structure and its chemical properties. Computer (or molecular) models are defined as products of quantum chemical calculations and assist in a visual demonstration of substances structure. However, they also present the characteristic, in this case, the distribution of electron density in the molecules of amino acids which is the cause of physical and chemical properties of the molecule. The colour range indicates electron density distribution. The blue colour displays a low electron density, while the red colour high electron density. The computer models used in the experiment are shown in figures 1, 2, 3 and 4. These were the amino acids: alanine, phenylalanine, glycine and lysine.

The Progress of Experiment

As already mentioned, the pedagogical experiment method was used for data collection. In total, 35 students of two parallel classes, 10^{th} A and 10^{th} B, so called upper classes, took part in the experiment. Prior to the realisation of the experiment, the students were divided into two groups, the experimental and

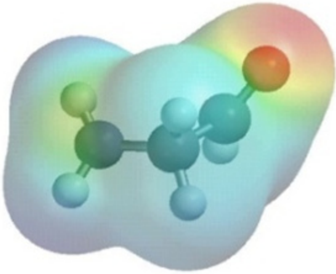

Figure 1. – The computer model of glycine.

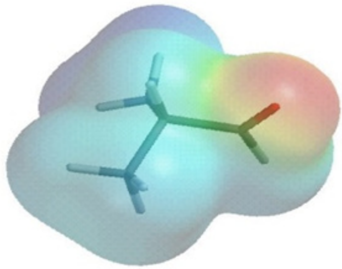

Figure 2. The computer model of alanine.

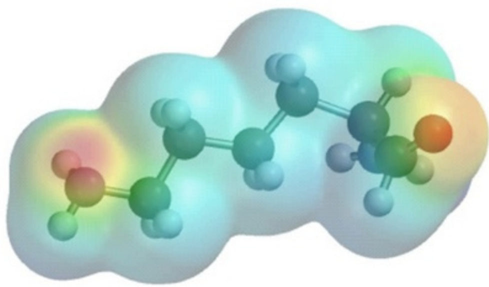

Figure 3. The computer model of lysine.

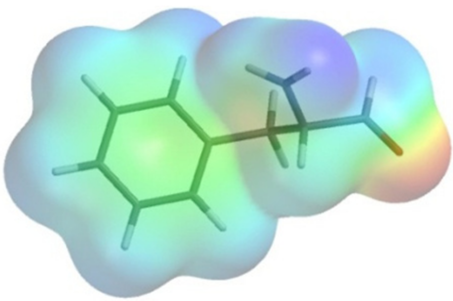

Figure 4. The computer model of phenylalanine.

the control. Students were chosen in groups deliberately, based on their results in the pretest. Teaching with the support of computer models took place in the experimental 10^{th} A class, whereas in the control group, the curriculum was introduced in the traditional way, which means without any innovative means support. Both groups were given a pretest to determine the initial knowledge of grammar school students and at the end of the lesson students were given a posttest, which serves as an indicator of students' knowledge at the end of the lesson. The tests were designed in such a way which does not give any advantage to the experimental group. The pedagogical experiment was realised in the time schedule of the curriculum in April of the academic year 2015-2016 and it was carried in the Russian language. The tests were translated into the Russian language and consulted with the local teachers. The presented pretest and posttest were identical and these tests were divided into thematic areas whose structure was as follows: introductory part, containing a request for filling in the tests, the initial questions related to amino acids and their chemical and physical properties. The test included open-ended questions and multiple choice questions. Multiple choice questions have the disadvantage of possible random choice of the respondent, that's why 20 questions were processed and test tasks offered at least three options, maximum was four options. Analysis of student's obtained points from the test was performed by using student's t-test (Lašek, Maněnová, 2009). The statistical data processing was carried out using STATISTICA12.

The aim of the research was to determine the effect of computer models use in teaching chemistry within the thematic unit amino acids on the results of grammar school students of 10^{th} A and 10^{th} B; i.e. to compare students' knowledge acquired in the classroom with the support of computer models and the results of the respondents without their support. Hypotheses were formulated as follows:

H_0: There is no statistical difference between the experimental and the control groups.

H_A: Students who participated in teaching with computer models are more successful in the test than those who participated in the traditional way of teaching.

Summary of points gained from tests

Table 1. Number of points obtained in the pretest of grammar school students.

Class	Number of points in the pretest
10. A	46
10. B	57

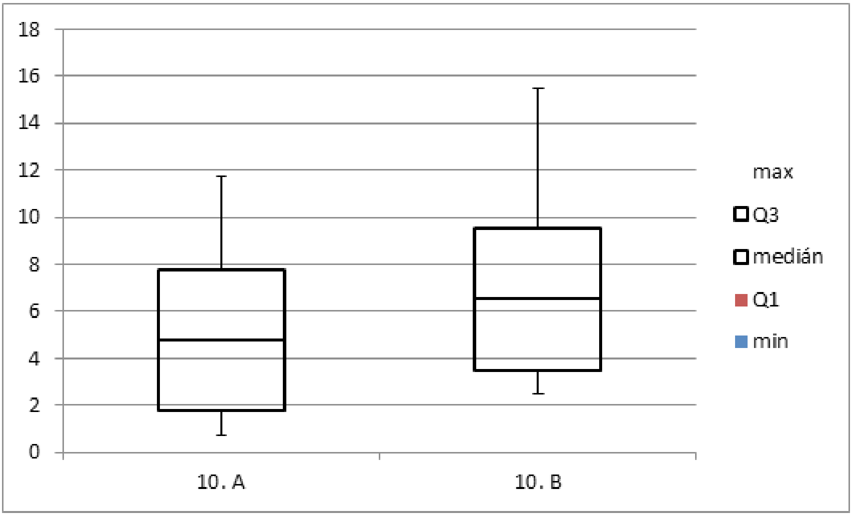

Figure 5. Graph – Graphical presentation of test point's obtained in the pretest of grammar school students.

Table 2. Number of points obtained in the posttest of grammar school students.

Class	Number of points in the posttest	
	The experimental group	The control group
10. A	148	96
10. B	156	106

The pretest results indicate the fact that students already have some basic knowledge of amino acids which is in compliance with their existing practice. The education system has undergone a reform resulting in moving from a linear learning education to a concentric education which means that the students repeat the thematic sections during their education each time with a certain deepening of the topic.

Student's t-test was used for possible verification or denial of the null hypothesis because its use can determine whether the results of the two files, which are obtained from two different groups of objects, can vary in the arithmetic mean (Chráska, 2007). The T-test was used for groups of students with the aim to determine knowledge of students both in experimental and control group before the beginning of lessons and after them.

Figures of the standard deviation, mode, t-test, p-value, median and average number of points were calculated from collected data using programme STATISTICA 12.

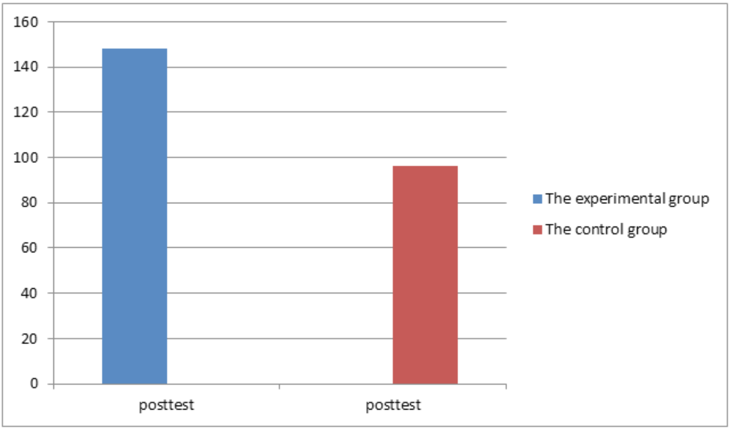

Figure 6. Graphical representation of test points obtained in posttest of 10th A students.

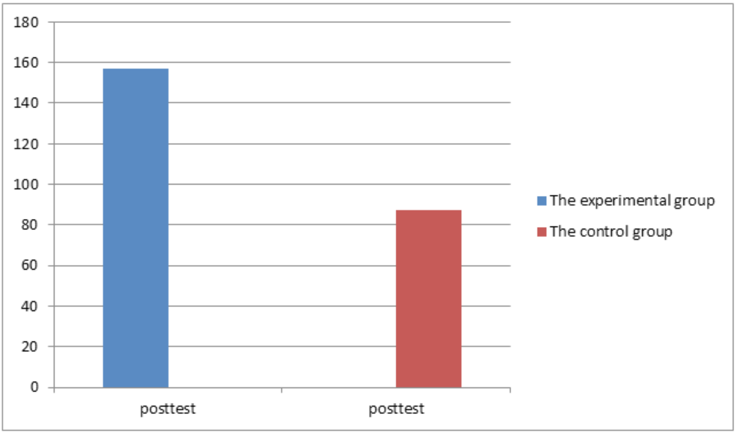

Figure 7. Graphical representation of test points obtained in posttest of 10th B students.

Calculation of t-test for 10th A

Table 3 demonstrates the data of 10th A students. T-value in 5.04 and from the average is clear that there is a difference between the control (9.6) and the experimental (14.8) group. This hypothesis is also confirmed by p-value of 0.00009, which is smaller than a significance level of 0.05, leading to the adoption of alternative hypothesis.

Table 3. Summary of results of the 10th A.

	AVERAGE	SD	min	max	modus	medián	t	p	H_0
Posttest K	9,6	2,6	6	15,0	10,0	10,0	5,04	0,00009	Accepting H_A
Posttest E	14,8	1,6	12,0	17,0	14,0	14,5			

Calculation of t-test for 10th B

Table 4 presents the results calculated for the 10th B. T-test value takes the value of 5.156 and the average value for the control group is 11.1; and for the experimental group - 18.5. Comparing the average values for the experimental and for the control group shows that these groups are different, which is confirmed by the p-value, which becomes 0.00008, and which is less than a significance level of 0.05. Based on these collected data, it can be stated that both groups provide statistically different results.

Table 4. Summary of results of the 10th B

	Průměr	SD	min	max	modus	medián	t	p	H_0
Posttest K	11,1	3,6	7,0	16,0	7,0	13,0	5,2	0,00008	Accepting H_A
Posttest E	18,5	2,2	15,0	24,0	19,0	19,0			

Conclusion

There's sometimes occurs an imaginary barrier between teacher and pupil, in which case it is not a cultural barrier, yet a language barrier from a certain part, which leads to students' misunderstanding of learning materials. As the teacher would speak another language and the students did not understand. This problem occurs predominantly when teaching Science subjects which require an abstract thinking and no all students are capable of it. This causes the declining interest of students and the increasing unpopularity of these subjects. The interpretation of some chemical concepts and phenomena is hardly imaginable for students, so the need of visualization arose, which relies on new technologies developing. Computer models serve as a didactic tool, which affects students' motivational component and activates their attention.

The aim of the investigation was to determine whether the computer models are an effective tool in organic chemistry teaching in the context of the thematic part - amino acids.

The present survey provides a rough orientation of the effectiveness of teaching using computer models at grammar-type schools in Penza. The realised survey shows that the computer models used in these classes were seen as an innovative tool that encouraged students' imagination.

Furthermore, the test results indicate that used computer models help students to understand the curriculum, i.e. students learning with the support of computer models have achieved better results than those of the students working without using models. Besides other things, computer models were positively perceived, both by grammar school students as well as by the teacher.

The results of the presented investigation linked to the surveys already undertaken, which, however, were implemented in the Czech Republic, confirms the benefits of computer models in teaching and better results in solving of the tests in the experimental group of students (Marek, 2013).

Students in the experimental group received the test, which reflects the positive impact of the application of models to improve teaching quality.

Acknowledgements

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Kahoot! As an Examinational Tool at University Level

Introduction

The term exam become from latin word examen and it means

The term exam comes from the Latin word examen and means the study of knowledge (understood as knowledge, skills, habits and attitudes) of the examined person.

Classification of examinations

The exams can be divided according to different criteria:

- in view of the form of taking the exam: oral, written, computer and manual.
- Due to the access to information - so-called open book exams (the exam sheet, questions and tasks contain information precising which materials can be used during the exam) and closed book exams (traditional exams during which students answer questions and solve tasks independently, without any help and without materials). There are also exams that students are solving tasks and answer questions independently at home. The purpose of such exam is to check not so much knowledge as to understand the problem, just like an exam whare using materials is allowed. The most common form of this type of exam is an essay, report, presentation.

We can also talk about formal and informal examinations (formal exams include, for example, driving license test, matriculation examination, but also an exam in college). The next category of the division is the way of assessment of the examinations: external exams (mostly state), in which the results are evaluated by teachers from other schools than the one in which the exam was conducted, and internal examinations (carried out by teachers of a given school - such as colloquia, quizzes and tests).

From the point of view of the above presented classification, the exam at the university is an internal and formal examination, in the case of natural science courses it is usually an "open book" test and is in written form.

Tests as a form of the exam

In practice, for purpose of exams at the university relatively often tests are used understood as any properly constructed, objective test, which results are quantified. Tests are checking achieving effects of education that are defined in the course card.

In the case of educational achievement tests, the following types are distinguished:

1. according to the measurable character of the student's achievements:

- power test - it checks the accuracy of the student's mastery of a certain type of activity. It consists of tasks with diverse content and varied difficulties. Limiting working time is in this case only ordinal and - in principle - every student can perform the whole test.
- speed test - checks proficiency in mastering activities that should be automated, eg reading, counting, Usually consists of tasks with homogeneous content, relatively easy for students, but in such a quantity that - in principle - no student could perform the whole test in a set time, usually just a few minutes.

2. depending on the adopted reference system:

- checking test - contains content selected due to curriculum requirements,
- the final summarizing test (in case university studies the exam finishing the couse) consists of a greater number of tasks that all students solve, which makes it possible to objectify the assessment of student achievements,
- multilevel checking test - checks whether program content has been mastered and to what extent,
- a differentiating test - the content of the test is selected in such a way to show differences in the current achievements of individual students; this type of test is mainly used for selection purposes, it is built to highlight differences between subjects, but it does not say whether any requirements are met. (A special variation of the differentiating test is the selection test, which aims to divide students into two groups according to some external criterion.)
- diagnostic test - it is used to check any complex activity; the feature of this test is to discover the reasons for possible errors,

3. according to the level of advancement of the construction and its complexity:

- standardized - those are tests that have undergone trials, improvements and norming on a large population,
- non-standardized (informal),

4. due to the range of use:

- wide-use tests (mainly state exams),
- teachers' tests,

5. due to the activities performed by the tested persons:

- oral tests,
- written tests,
- computer tests
- manual tests

From this point of view, tests at universities can be classified as non-standardized teacher's tests, power tests, mostly in written form.

Construction of tests

Two types of tasks can be used in the tests: open tasks, in which the student constructs the answer himself, and closed tasks in which the student chooses one or more of the answers given to him. Open tasks can have various forms, they can be tasks of extended response (where we include verbal activities and symbols), short answer (single response, enumeration), tasks with a gap (completion, correction). In contrast, closed tasks can take the form of matching tasks (where we include: assignment, classification, ordering), multiple choice (one true answer, one false answer, the best answer, variable number of answers), true / false tasks (alternatives selection, scaled choice) . The advantages and disadvantages of both types of tasks are presented in the table 1.

Table 1. Open and closed tasks - a comparison.

	Open tasks	Closed tasks
Advantages	they are easy to construct, they do not suggest answers, they show the student's work flow, they allow students to demonstrate independence and often the originality of the problem solution; it's harder for students to cheat	easy to check, even at large numbers of groups ensure the objectivity of scoring, a large number of tasks are possible in the test (good representation of the teaching content) creating parallel versions of the test is relatively easy; well-structured stimulates the student's thinking processes, putting him in a decision-making situation
constraints	they are time-consuming while assessed scoring of the results may be not very objective the number of tasks in the test is usually small (poor representation of the teaching content), it is difficult to create a parallel version of the test; writing answers is time-consuming	they are difficult and time-consuming to construct; they suggest a response; the way of achieving the result can not be determined, student's individual abilities cannot be captured answers selected by students may be accidental (guessing), they are easier for students to cheat

Taking into account the advantages of closed tasks (Table 1), most written examinations at universities are currently in the form of closed tasks tests.

On-line tests

Currently, some teachers, including academic ones, use on-line tests during examinations, this is in line with the SAMR concept by Ruben R. Puentedura (2014). There are quite a lot of websites on the web that allow to create surveys and various types of quizzes / tests. Some of these sites even allow to attach graphics and multimedia files into the test. Environmental (tests do not have to be printed - paper can be saved up) and economical (time for checking correctness of answers can be saved up) considerations speak for using on-line tests. Below there are presented the most commonly used free programs for creating surveys / tests, including programs with additional non-standard options.

Google Forms

Google account holders can create surveys (and recently also tests) with the help of the Google Forms tool. In the test both open and closed questions can be created. Questions can be enriched with videos or graphics.

The program allows you to mix answers and questions. In closed questions, you can set a score (the test prepared in such way immediately gives results to the student). If the test contains open-ended questions, the grade is sent to the student at his email address after evaluating the open part by the teacher. The results of the conducted survey are automatically imported into the Google spreadsheet, where you can additionally use an interesting tool for classification and assessment with the help of the free Flubaroo plugin (http://www.flubaroo.com/).

Moodle

Also, remote learning platforms offer the opportunity to test knowledge in a test form (known as the Moodle Quiz). The advantage of creating an exam for the Moodle educational platform are the large technical possibilities (described below), however, students participating in the exam must be enrolled in a course on the platform. An unquestionable advantage of the Moodle tests is the ability to set the date of the exam (without setting the time, the teacher manually activates the test, the test parameters are set automatically) and its time.

In the time parameters, students may be allowed to take the same exam multiple times (then the time between individual approaches is determined). You can also determine the variable order of questions in the test and the variable order of answers in the question. An interesting solution is the so-called an adaptive mode that allows students to learn while taking the test. This mode allows you to define the “behavior” of the test in Moodle, depending on the student’s answer to each question. Adaptive mode has several levels of the most advanced, it allows you to display different feedback on subsequent approaches, and even change the content of the question. Such large possibilities, however, require a good knowledge of the program by the teacher and take a lot of time to create such a test.

There are several types of questions in the Quiz (computational, simplified computational, multiple-choice, descriptive, elaboration, matching, attached questions (Cloze), multiple-choice, random matching of short answers, short answer, numeric, true / false) depending on the version You can also add custom questions or import tasks from other platforms such as LearningApps or Hot Potatoes

Quizdini

An interesting solution is Quizdini (http://www.quizdini.com/) because the ability of creating explanations for the answers given by the student is available, so the pupil can get an extended explanation - automatically after answering the question. In this description text, links that lead to external resources with graphics or video files can be placed. Quizdini therefore includes the ability to learn a student during the test - this is a rare option.

Zoho Survey

A very extensive tool is Zoho Survey (http://survey.zoho.com/). It allows you to choose from dozens of different formats of answers, as well as to specify them, eg specifying the maximum number of characters entered. We can also use the logic formula “if - then” when designing a quiz, which means that on the basis of a answer given by the user a specific set of questions will be assigned to him. You can paste the finished test into your own website using the generated code or provide a link to the quiz. A helpful option that can be used is the ability to specify the date after which you can not answer the questions and limit number of possible answers (eg only one answer can be given from a specific computer).

ImageQuiz

A different approach to testing is presented by ImageQuiz (http://www.imagequiz.co.uk/). This tool allows to create quizzes based on drawings. In order to solve the quiz the user has to select the right part of the image, which is the answer to the given question. This tool is ideal for creating geographic tests, eg you can upload a map with a question about the location of the city, lake or mountain peak, or image-based selection tests (eg among the drawn structural formulas, indicate the sucrose formula, indicate where in the drawn molecule a nucleophilic attack occurs).

Wondershare QuizCreator contains 18 types of question types that can be used. Various tasks can be created in which the user, among others selects one/a few answers, gives a descriptive answer or indicates something in the picture. Each of the questions can be enriched with sound material, video or graphics. Interesting feature is a possibility of skipping the questions and come back to them after answering the other ones. In turn, the user creating tests has the ability to define the number of points to obtain for a given question and to personalize notifications about the correct / incorrect answer. The program automatically displays information about its result after the test. What's more, the results of quizzes for individual people can be sent to the indicated e-mail address.

Kahoot!

It is a free widespread game-based learning platform that makes it fun to learn – any subject, in any language, on any device, for all ages! Kahoot! is a free game-based learning platform, as educational technology. This is a free platform for creating and conducting interactive quizzes and tests. Its main advantage (which decided about the choice) is the fact that computer classroom is not necessary to be able to carry out the test because students use their cells, tablets and notebooks to answer. Since every remote controller is assigned to a given student (by entering the student's name), all information about the answers received or the time after which they were given are registered in the system, individually for each examined person. Questions are displayed using the projector on the screen, and the answer symbols are displayed on the students' cells / tablets / computers. The system allows immediate, automatic evaluation. The percentage of correct answers is displayed to the student on his cell immediately after answering the question. Additionally, on the general board, a ranking is displayed after each question (the sum of the previous correct answers and points for the response time - the faster the student answers the question, the more points he will get). This introduces an element of competition during the test.

The teacher can collect data on both individual students and the entire class team; data concern both the entire exam and individual questions, response times. These data are already pre-designed statistically (the teacher also has the option of further processing, eg in Excel), they can also be transferred to text files (eg doc, rtf, pdf) or graphic files (all kinds of charts). This makes it easier for the teacher to analyze the test, to divide the question into easy and difficult or even to follow the development of individual students.

Currently, there are 4 task creation types to choose from:

1. Quiz - allows you to create a multiple choice test with any number of questions containing from 2 to 4 answers, questions can include image, sound, or video; you can enter subscripts and superscripts indexes and mathematical symbols; the quiz allows to evaluate the correctness and speed of students' answers;
2. Jumble (setting in order) - similar to the Quiz, but here the student's task is to set in the correct order 4 consecutive elements (eg the first 4 alkanes in the homologous series); the task allows you to asses the answer, therefore you can create a test based on this type of task;

3. Survey - has the same features as the Quiz - but oposite to the quiz and Jumble, the teacher does not mark the correct answer, so there is no points system, after answering the question you can see a bar graph that shows how many students chose the answer, the tool allows to check what the students already know about the topic or as an introduction to the discussion,
4. Discussion - a tool similar to Survey - but you can only ask 1 question,

Kahoot allows the user to select one of two modes:

- classic - user can check the knowledge of each student individually then every student works on his / her phone / tablet,
- team mode - students can work in groups - then one phone / tablet is used by several students.

Advantages / disadvantages of the Kahoot tool

Kahoot was chosen after years of trials with various online testing tools. Although it seems to be the most friendly from the market, it also has its drawbacks. The most important of them are discussed below.

Advantages :

- Kahoot test database contains more than 13 million ready-made tests (and is constantly growing), because most of the tests are in the public domain, you can create your own test but you can also use or modify tests prepared by other users
- ease and speed of test creation;
- possibility of using subscripts and superscripts (priceless for chemists);
- you can set the response time (from 5 seconds to 120 seconds);
- you can add a photo, video from Youtube or its fragment (the start and ending time can be set - the time of the presentation of the film is not included in the response time);
- detailed analysis of students' answers (the initial analysis is carried out by the program itself);
- in traditional tests it is difficult to check the laboratory skills of students - the ability to observe and draw conclusions - in paper versions usually a verbal description of the experience appears, on the basis of which the student has the conclusions - the accuracy of such pseudo-laboratory tests is doubtful, such tasks in the first place they check the ability to understand the text being read; the use of films presenting experiments in the Kahoot (image + sound) tests creates a task situation for pupils in which they will be able to answer the same questions based on the received observations (just like in a real laboratory).

Disadvantages

- a fixed order of questions and answers in the test
- it is impossible to check the ability to write equations of chemical reactions, drawing structural formulae (but this is a challenge in any tests with closed questions)
- element of competition (after each question a list of the first 10 people with highest score is displayed) - it does not work well for everyone
- the need to work with "equal front", some prefer to bend over the test in silence
- difficulty in assessing how much time students will need to answer specific questions

Pilot studies

In Poland, from the beginning of the twenty-first century, several research was carried out on various applications of interviewing systems based on analogous principles as described above in case of Kahoot, however, requiring specialized interviewer kits [Paśko, Rosiek, 2004; Błasiak, Rosiek, 2005; Gulińska, Bartoszewicz, 2006, Nodzyńska 2009]. Since Kahoot does not require additional equipment, in the academic year 2015/2016 it was introduced as a permanent element of teaching students - both as a tool for collecting students' opinions, researching their initial knowledge, quick tests, colloquia or even final exams. In the 2015/2016 academic year, it was decided to introduce a test exam for the 2nd year of geography (chemistry course) using the Kahoot! In previous years, students during the exam solved the test in the traditional (paper) version.

Description of the test

The test consisted of 71 questions concerning all the material from the chemistry course (laboratory classes and lectures) for geography undergraduate students, . In the test predominated the questions of selecting 1 correct answer from 4 (Tab 2).

Table 2. Number of questions of different types: division by the number of possible answers

type of answer	selection 1 of 4	selection 1 of 3	selection 1 of 2
the number of questions	56	8	7

The average time assigned to answer one question was 37 seconds. The number of questions and the set time is shown in Table 3.

Table 3. The number of questions of different types: the division due to the time assigned to students to answer

time reserved for answers	90s	60s	30s	20s
number of questions	4	16	30	21

A detailed analysis of the students ‘answers shows that the time of answering particular questions has been properly selected (the average time of students’ answers to particular questions did not exceed 60% of the time given to them).

The questions had a very rich content:

- as many as 27 questions contained photos / drawings (also with chemical reaction equations),
- 16 questions contained videos with the chemical experiments presented,
- 5 questions contained models of molecules, chemical equations also in the microworld level, structural formulae.
- 4 questions referred to solubility tables,
- 2 questions contained a longer text for analysis (inserted in the form of a drawing),
- 1 question contained the periodic table,
- 1 question contained an infographic,
- 1 question contained included tables and formulas,
- only 14 questions did not have any additions.

The questions were varied not only in terms of additional material, but also if we take into account the category of verified knowledge according to Bloom’s taxonomy.

Table 4. Number of questions of different types: division based on the Bloom taxonomy.

Category of Bloom’s taxonomy	knowledge	understanding	application	analysis	synthesis	evaluation
the number of questions	28	7	7	15	14	0

Questions concerning the knowledge required students to extract from the memory previously learned material by recalling facts, terms and basic concepts (they required, among others, knowledge of the specificity of a given subject of its terminology, specific / basic facts). In order to answer the questions concerning understanding, the student had to show understanding of facts by organizing, comparing, translating, interpreting, describing and determining the main ideas. Questions about the application forced students to solve problems in new situations by using the acquired knowledge, facts, techniques and principles in a different way than previously known to them. Tasks belonging to the analysis type required the students to analyze the information provided to them and to draw conclusions in support of theories. Synthesis tasks required compiling all information in an innovative way by combining elements into new structures or proposing alternative solutions. The test did not ask questions from the highest category - synthesis, because it is difficult to formulate a closed question in such a way that the student could present and defend his opinion by expressing judgments about the rightness of ideas or the quality of work based on the objectives.

Test results - student's marks

Previous experience has proven that for most geography students chemistry is a difficult subject. However, despite the fact that the level of difficulty of the Kahoot test was comparable to the tests from previous years, the grades obtained by the students are significantly higher: results from 75% to 59% - marks below 2.5 for the oral question (fig. 1.).

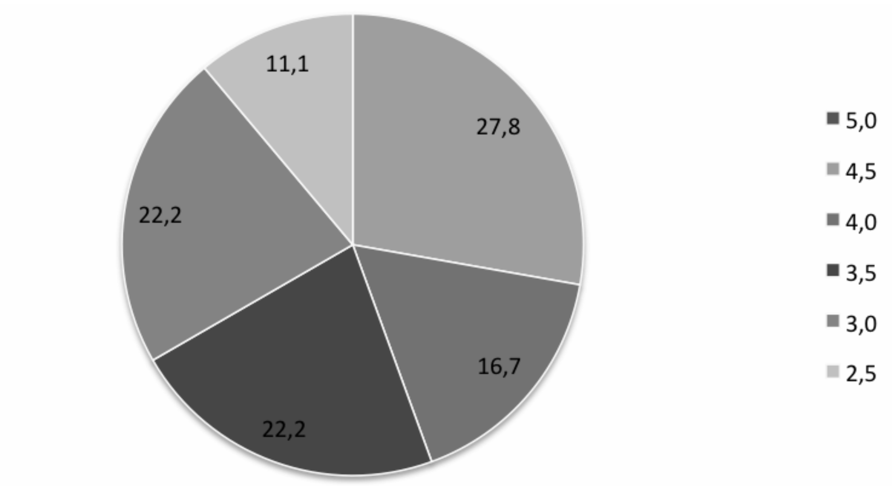

Figure 1. Studetnt's marks gained.

For 14 questions from 71, all students answered correctly (that is 100% correct answers were received), which is 19.7%. Among these questions the most numerous were represented questions belonging to the 'knowledge' category, it was as many as 8 questions (Tab. 5).

Table 5. Number of questions that all students answered correctly with regard to Bloom's taxonomy.

type of a question	knowledge	understanding	application	analysis	synthesis
number of questions	8	2	0	2	2

It can be considered, according to Bloom's taxonomy, that questions referring only to knowledge are the easiest for students. (However, for 28 questions in this category only for 8 questions all students answered correctly).

Detailed analysis of both response times, correctness of the answer depending on the type of question or correctness of the answer depending on the attached resources (video, drawing, etc.) did not show strong dependence. Only the use of the movie fragment in the question resulted in a slight increase in correct answers - but this requires further, more detailed research.

However, an interesting result obtained is the result of examining students' well-being after the exam. Because Kahoot! allows you to evaluate, among others feeling after solving the test and evaluating the 'playfulness' of the written test, this element was finally used. Pretty surprising results were obtained: On the five-point scale, students rated the test's 4.40 fun (4.40 out of 5). The mood after the test (but before getting to know the final grades) was rated very positive (78%) or neutral (22%). It's rare to feel good while taking the exam.

Table 6. Students's feelings after the examination.

How do you feel?	Positive	Neutral	Negative
	77,78%	22,22%	0,00%

Summary

Kahoot! it's a quick, easy tool for creating tests. The possibility of automatic test analysis allows to modify the test in the following years. Analyzing student response time allows to adjust the time when next time the same test is used. Since the test results are also automatically calculated for the whole group too easy or too difficult questions can be removed in the following years.

At the current stage of research, it seems that the use of film fragments in questions makes it easier for students to recall their experiences from laboratory classes and enables to answer these questions correctly. This tool can be used for purposes of the exams at university level instead of traditional paper form, however it requires appropriate preparing the test.

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Awareness of Ethical Behaviour Related to the Functioning of the Internet, in the Teachers Opinion

Introduction

One of the major achievements of modern civilization and culture is undoubtedly the creation of the Internet. Ranks among the most modern and still developing media, information and communication and education. Using it gives a very large benefits in the everyday people functioning but also is a place of many threats, which do not always realize.

The study shown analysis of the replies to the questions in the survey, which allowed the analysis of the ethical principles declared surveyed teachers.

The aim and object of study

The subject of research are the opinions of teachers from elementary school, middle and high school about the risks and comply with ethical principles on the Internet. The study was conducted in order to diagnose awareness of ethical behavior related to the teachers functioning on the Internet.

The research involved questionnaires that were completely anonymous. In order to obtain an accurate picture of a consciousness of ethical when using the Internet by the teachers they used a questionnaire containing 16 questions addressed to teachers, consisting of three parts: introduction, in which were included information about the purpose, content and manner of providing answers and the total anonymity of respondents. The second part of the survey included closed questions, which were prepared in advance sample answers single and multiple choice - the so-called. closed questions conjunctive.

Characteristics of studied group

The study involved 300 primary, middle and secondary schools in among them were two hundred and fifty women and fifty men.

The course of studies

All respondents participating in the survey at the beginning was presented research objective, which agreed, showing a huge interest in the issues. They gave willingly answers to the questionnaire, did not have any problems understanding questions.

Studies conducted in the teaching profession and clearly show the degree of awareness and the conditions with which meets the average teacher in various stages of development of their wards.

At the beginning they asked about young people's access to the Internet and collected opinions on the frequency of using the Internet.

Fairly well is the situation in the evaluation in terms of how often youth has contact with Internet. Definitely the best look is high school up to 97%, then 63% of primary and 40% secondary school. To use once a week, admits 30% of pupils from the primary school 50% of high school and only 13% of high school students. Contacts to the Internet at least once a week by has 7% of pupils in primary school and 10% of high school.

1. Do you have a personal computer with Internet access (fig. 1).?

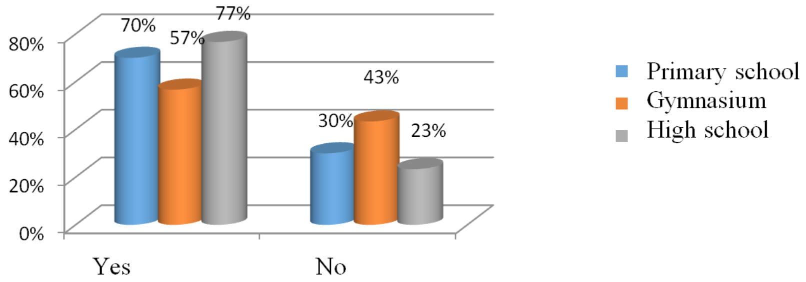

Figure 1. Having a computer with Internet access by the teacher.

Having a computer with Internet access showed 70 - 77% of teachers from primary and secondary school, while only 57% of high school, also most teachers from high school said that they do not have their own computer. It was 43%. Only 30% of teachers from primary school and 23% of high school also did not have your own computer with Internet access.

2. For what purpose your students frequently use the Internet in free moments?

Giving free time to youth, we can easily see what they are most interested in staying on the web. According to the observations of teachers 73% of young people from primary school play games, 50% browsing the web, 27% use e-mail or chatting, 60% of searches for the necessary information, while 40% take the time to learn and only 7% of students of their time devoted to other actions.

Less interest in games exhibit high school students and high school, 30% and 27%, respectively. In contrast, as much time is spent on chatting and surfing the internet, only 23% of dedicates to science.

27% of respondents in the oldest group showed interest in the games, 43% spent time browsing web pages, of 33% for use of e-mail. By far the least spent time chatting, because 23% up to 60% on the search for information, and what is comforting -30% of pupils learn from web pages.

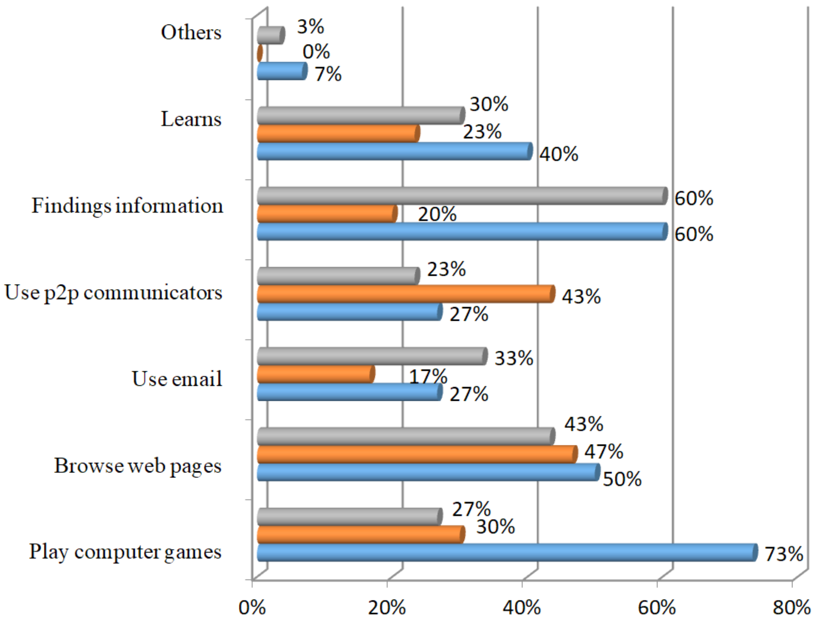

Figure 2. The objective for using the Internet in a free moments for students.

3. Do you participates in discussions on the web forums?

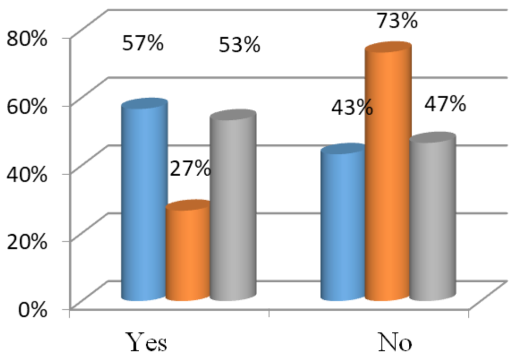

Figure 3. Participation of teachers in discussion forums.

More than half of the teachers declared participation in the discussion forums. From elementary school and high school a respectively 57 - 53%, and 43 and 47% of these same schools admitted that they had never taken part in a discussion in such forums. Adverse situation in the gymnasium. The teachers admitted that only 27% took part in discussions on the Internet, and as many as 73% of respondents say they did not participate in any discussion forums at all.

4. Do you participates in the training courses conducted over the Internet and have completed them?

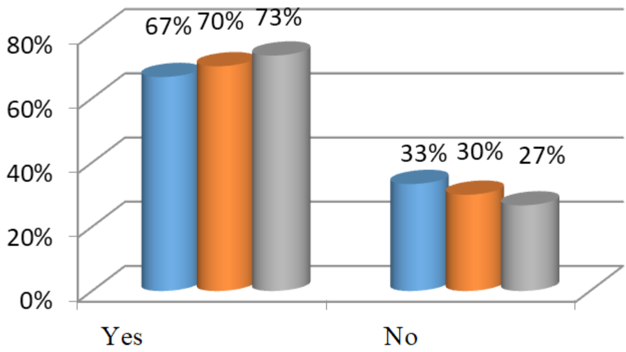

Figure 4. Participation of teachers in training over the Internet.

Two-thirds of teachers from all types of schools participated in training online via the Internet and completed them. Only 33% of primary school, 30% of high school and 27% of high school said that they had never participated in such training.

5. Did you publish on the Internet their own materials?

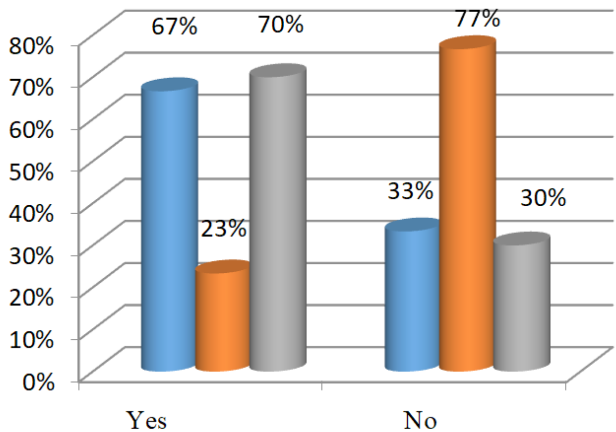

Figure 5. Share of teachers in their own publications.

The vast majority of teachers, 67 and 70% of primary school and secondary school stated that they placed their own publications on the Internet. Whereas publishing such content declared 23% of the teachers of the school.

6. Do you think that education on threats from the Internet is in question?

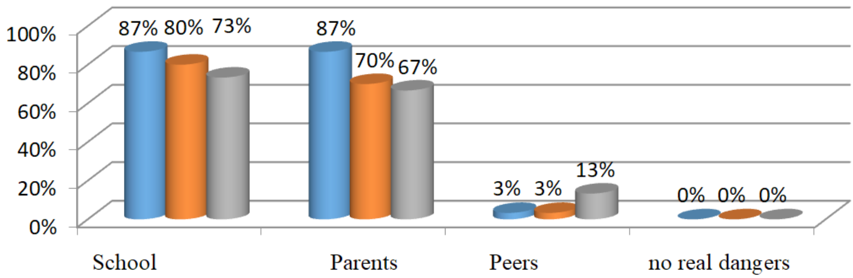

Figure 6. Education in topic of the dangers of children from the Internet and is it in the question.

Like parents, teachers believe that education on threats on the Internet is not only the parents work but also should be the goal of teaching in the school. Only 13% of high school teachers and 3% of the primary school and secondary school believes that with such threats should inform by peers.

7. Did you take participation in the training course on network security?

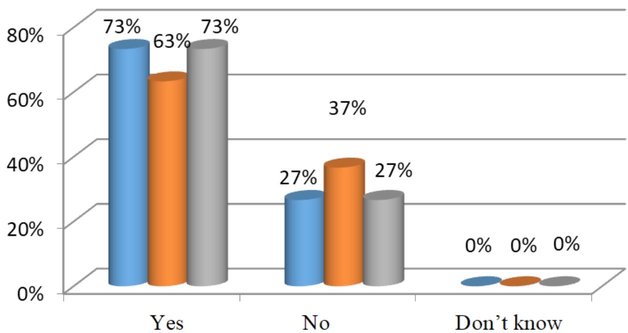

Figure 7. Participation in training on Internet safety.

Teachers declared that 73% of primary and the high school have participated in training on security in the network. 63% were teachers from the school. Such training is not passed 27% of teachers from primary and secondary school and up to 37% of secondary school teachers.

8. Did during the classes talked about the problem?

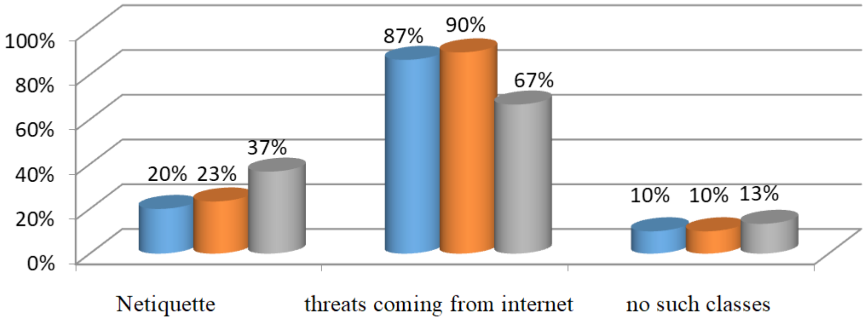

Figure 8. Classes about netiquette, online threats.

Too little classes is still conducted about netiquette, because only 20% of primary school, 23% of secondary or 37% in high school. Whereas 87% of primary school, 90% in middle school and 67% in high school are take on the threats coming from the Internet. About 10% of all types of schools declared that they do not carries such classes.

9. Does your computer in your class has such features as: antivirus, parental lock, firewall, etc. ?

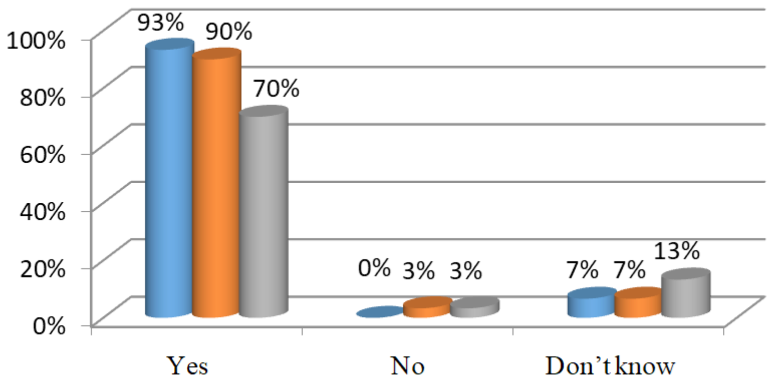

Figure 9. Use of security in the computer school.

A large percentage of teachers said that computers of their classrooms are well protected, as much as 93% of teachers from primary school, 90% of high school and 70% of high school. Only 13% of high school do not know it and 7% from other schools.

10. Are you are aware of the legal consequences, which are subject to your children using eg. The illegal software or play of hacker?

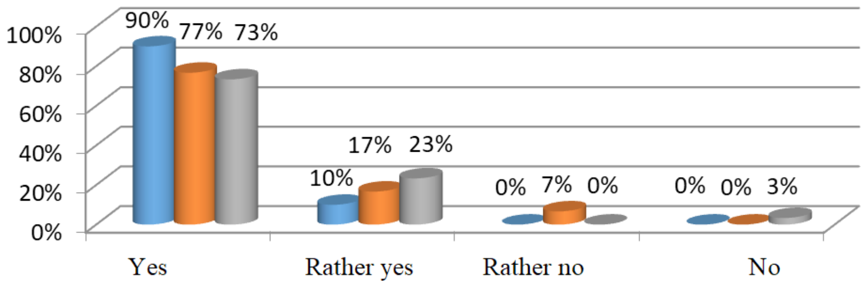

Figure 10. Awareness of the consequences of non-compliance on the Internet.

Awareness of the legal consequences of failure to comply with legal knowledge that is very high. It ranges from 73 to 90% among teachers in all types of schools. Ignorance about this ranges from 3% in high school to 7% in the school gymnasium.

11. What kind of risks that can meet children on the Internet, you fear the most?

Concerns teachers are addressed in decisive extent on game addiction, from 70 to 77% of high school. The next thing are afraid of teachers from primary school are impoverishing people contacts-57%, pedophilia-43%, breaking the law-43%, 47%-pornography, promotion of drugs-47% recruitment to sekt- 40%. Teaching staff of secondary school beyond the addiction to games is also afraid violation of the law 57%, loss of of interpersonal bonds 43%, 27% of pedophiles, pornography, 50%, of promoting drugs 37%, and the recruitment for sects 27%. Similar concerns shared by teachers from high school with an emphasis in addition to gambling addiction on the depletion of contacts 47%.

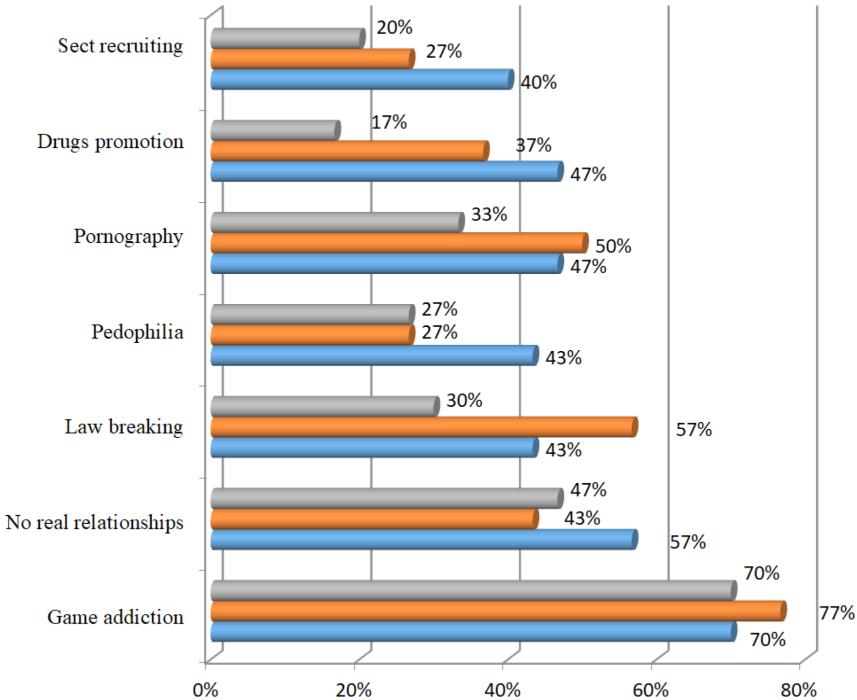

Figure 11. The risks children can meet on the Internet.

12. Are your students ever had contact with these or other risks?

The question is not one of the questions that are easy, because it has an impact on the experience, knowledge and professional approach of the teacher to the student that if necessary he is helping. The vast majority of teachers, unfortunately, do not know nothing about this . Most from an elementary school 60%, 57% of middle school and 47% of high school. Studies have shown clearly that the most common symptoms of breaking the law is violation of copyright on believe that 27% in high school, 10% in high school and 7% in primary school. The alarming fact is that as much as 20% of high school students and 13% of primary school pupils met with phishing data. With pornographic met 13% of high school students and 10% of students from middle school.

Very disturbing is the fact that young people from an elementary school and secondary schools 10% 13% was urged to meet with strangers met on the Internet.

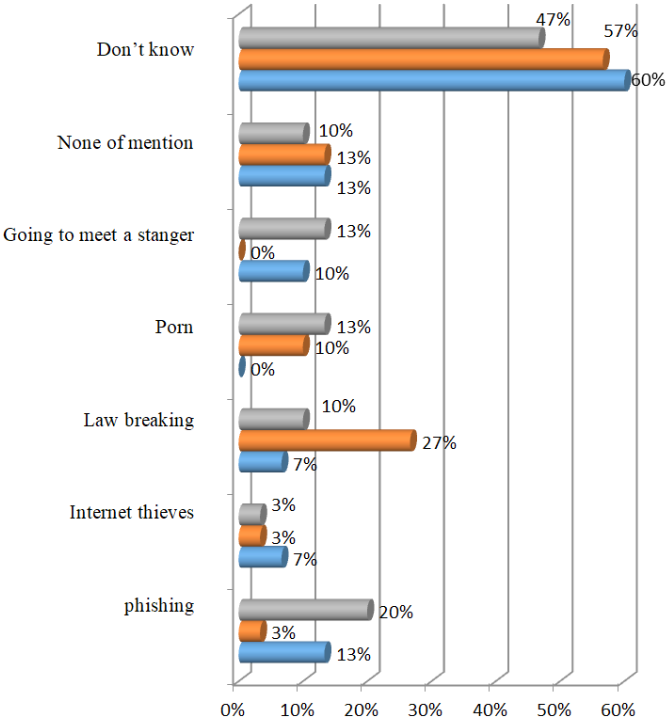

Figure 12. Risks that may meet on the Internet.

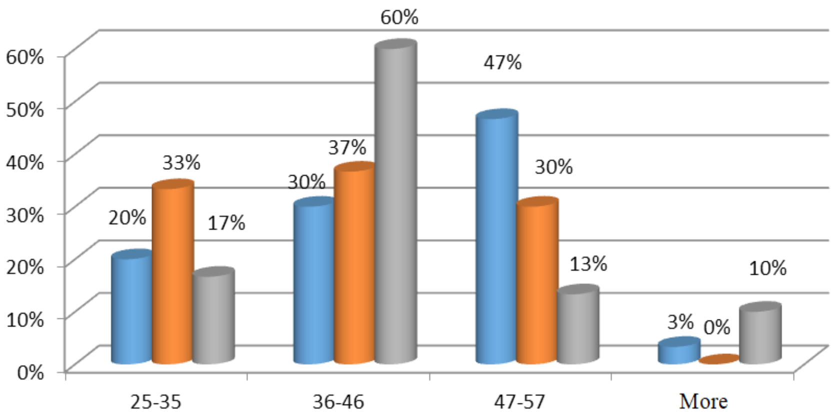

Figure 13. Age of teachers involved in the studies.

The age range of the teaching staff was located an average of 25 to 57 years. Teachers who slightly exceeded this age range are 3% of teachers from primary schools and 10% of high school. The vast majority of teachers participating in the study are people with extensive professional experience - aged between 36 and 57 years of age.

Summary

Internet becomes something timeless, unrestricted spatially, where the way of information takes a consecutive day and night throughout the year. It lives his life, constantly develops, improves, expands and enriches.

The rapid development brings with it not only what is good, but unfortunately also risks that can meet Internet user.

Research conducted by TNS on behalf of Orange Poland and the Nobody's Children Foundation showed that 90% of parents admit that they are responsible for the safety of their children on the web. But in everyday life, unfortunately, this responsibility is often flips on teachers.

Analyzing studies one can accurately determine the needs and the risks faced by a young man who uses the resources of a global network. Undoubtedly, the primary oversight on the part of parents is to leave children without adult supervision-alone Internet in their locked room.

The level of knowledge about threats such as making new friends, the administration of private information or even meetings with strangers met on the Internet for young people is not enough. This is influenced by the fact that parents are not always interested in what their kid is doing on the network and often leaves them alone with the often uneasy decisions or even problems.

I believe, on the basis of studies that the only effective form of prevention is out of compliance with the given standards of ethical behavior of Internet users, in order to improve the relationship with the network.

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The Policy of Urban Greening in the Frames of Sustainable Development

For maintaining a balanced economic and ecological development of cities, it is essential to take into consideration ecological issues. A steadily increasing level of atmosphere and soil pollution with different harmful substances affects both the whole of urban ecosystem and condition of urban vegetation. One of key aspects of the conceprt of sustainable development of cities is urban greening which is regarded as an essential prerequisite for the health of urban communities and requires a novel strategy.

The research goal was to intorduce a scientifically sound method of urban greening as a teaching and educational tool in the ecological aspect of sustainable development. Taking into account the importance of nature management principles of sustainable development, an urban greening program was developed which consists of several research stages and has already been tested in the area of city of Yerevan.

The research included a study of pollution level of urban soils and atmosphere, assessment of condition of green areas and plant species composition, a study of metal accumulation and gas-and dust- accumulation properties of plants, and selection of an assortment of ecologically tolerant urban plant species. Data obtained were mapped using ArcGIS software. Also, data were collected regarding awareness and active involvement of students of different age groups in nature management programs.

It is suggested that awareness of different layers of the population and professional factors be taken into account when developing analogous program in the future.

Ecological problems the modern world is facing today have diverse aspects. The major cause of deterioration of environmental state has been contradiction between economy and the nature. To assure equilibrum between economic and ecological development one should take into consideration ecological problems. With this end in view it is possible to use natural resources applying principles “sustainable development” and “green economy” (Vasilenko, V., 1995). In recent years the adverse impact of manmande factor on the environment emphasizing urban one has increased. In this respect, one of key issues of the concept of sustainable development is urban greening that ensures health of urban population. Sustainable development is a a socio-economic structure the mission of which is to preserve natural resources and to rationally use them for the benefit of humans, and to improve the quality of life of generations.

In 2009-2011 the sphere of nature protection in Armenia was developing mainly in the frames of sustainable development (Abstract from RA, 2014). Since recent years many countries have been transitting to “Green economy”, the principles of which includes not only creation of ecologically safe workplaces and assurance of sustainable growth in economy, but also prevention of environmental pollution, global climate change, depletion of natural resources, and ecological degradation (Abstract from Yerevan, 2013-2015; Oleynik, E., M., 1999).

A nature conservation aspect of Armenia’s sustainable development program, along with other issues includes those of expansion and improvement of public green spaces such as parks, squares, urban forests and so on. It is also essential to apply “multistorey” principles of urban greening in order to create favorable microclimate, decrease levels of air basin pollution and noise pollution of the environment, saturate with phytocides (Hovhannisyan, H., 2015; Oleynik, E., M., 1999; Vasilenko, V., 1995; www.ncsd.am).

Formation of urban greening systems in modern ecological conditions is a key issue for optimal development and beautification of cities, improvement of ecological status, and sustainable development. In order to assure natural biological safety of urban areas it is necessary to create a target greening network. Target greening means a science-based greening aimed at assurance of sustainablity, longevity and functional use of of urban plants (Mkhitaryan, R., 2014; Abstract from Yerevan, 2013-2015; Publ.: Center for Ecological-Noosphere Studies NAS RA, 2007-2008).

To assure biological safety of urban plants and green areas it is necessary:

1. to take into consideration the degree of manmade load on adjacent areas,
2. to select appropriate plant species taking into account their tolerance to manmade factors.

Under modern conditions proper management of urban greening and urban plants is possible only in the case of harmonization of three basic directions of urban area management and urban greening: maintenance, development and control. Consequently, economic and ecological aspects of urban plants management, protection and maintenance are acquiring a special significance. First of all, particularly essential become processes of implementation of political decisions contributing to protection of green areas, necessity and encouragement of public involvement, speciliased structures and independent consultants in protection and management of urban plants. Nonetheless condition of urban plants in Armenia’s urban settlements does not fully meet requirements to ecological development of sites. Moreover, in Armenia there are no legislatively grounded incentives (designated for improvement of urban greening), that finally brings in emergence of unmanageable situations in respect of the use and renewal of green resources of urban sites (Book of statistical data, 2009-2011; Mkhitaryan, R., 2014; www.yerevan.am).

Monitoring condition of urban plants has a crucial role in protection and maintenance of species as it helps understand functional status of trees and compare it with respective criteria and earlier monitoring data in order to reveal the dynamics of ongoing changes. Besides, monitoring data are used when planning urban greening and site improvement and maintenance activities and elaborating on respective chapters of site development. It is suggested that an automated GIS-supported database be produced for each site to be greened in order to improve the quality of monitoring and management of condition of urban plants (Mkhitaryan, R., 2014).

The aforesaid are priority issues to Armenia's town and particularly to the capital city of Yerevan. The management of such issues requires development of novel strategic approaches with a view of assuring sustainable development of urban sites. According to estimates, presently Yerevan homes some 420 enterprises which have an adverse impact on the environment. It is a complex effect of these factors, which determine the presence of increasing harmhul contents of different gases in the atmosphere, for instance, a tenfold increase in environmental carbon. Wholly, a current status of Yerevan greening is not satisfactory and does not meet present-day requirements to urban greening, composition of plant species is poor and in most cases plants do not have hygienic, ecological and aesthetic roles they destined to. The assortment of tree and shrub species once intended for Yerevan greening was composed randomly and included species which in most cases did not tolerate conditions of the city. However green urban spaces are extremely important as urban plants have a property to absorb large quantities of different pollutants from soil and atmopshere. Condition of Yerevan trees and shrubs has dramatically changed over the last decade. Current data from Yerevan Municipality and National Statictical Service RA say that per capita green space is 5-8 vs.21-24sq.m (http://www.arlis.am; www.yerevan.am; Publ.: Center for Ecological-Noosphere Studies NAS RA, 2007-2008). The new Masterplan expected that Yerevan green areas should substantially increase since 2005 and green spaces be enlarged by 1300 hectares from 2015 to 2020. Data provided below help get a vision of the dynamics of Yerevan green spaces and respective prospects of the Masterplan for 2005 (Tab.1).

Table 1. Total indicators of Yerevan green spaces (ha). General plans in 1990 - 2004 and 2020.

Target purpose of a green site	**Dates**		
	1990	**2003-2004**	**2020**
Public green spaces	928.3	540.3	2382.0
Green spaces of limited use	2395.2	2951.3	3245.3
Special green spaces	2288.7	1460.1	2310.0
Total	5612.2	4951.7	9397.7

As seen from tabulated data, loss of green areas caused by site development between 1993 and 2003 was estimated to be 1216.6 hectares. According to the Master plan for 2005, it is expectable that green spaces throughout Yerevan should be substantially increased through newly planted areas and hence compensate for a current deficiency of 4446 hectares (including 1379.8 hectares of public green spaces). Moreover, if today per capita green space in Yerevan is 44.8sq.m, then in 2020 this index will achieve 78.3sq.m. The Master plan suggests restoring green areas and implementing new massif tree planting particularly in Yerevan suburbs (Danielyan, K., 2008; Publ.: Center for Ecological-Noosphere Studies NAS RA, 2007-2008; Mkhitaryan, R., 2014).

Presently, urban plants protection and completion activities are ongoing in Yerevan. According to official data from Yerevan Municipality, wholly as of 2014 public green spaces made 852 hectares, 158 of which fell on parks, 36.9 – on squares, 497.5 – on urban forests, 152.9 – on street lawns (8 Abstract from Yerevan, 2013-2015; Danielyan, K., 2008; Abstract from RA, 2014).

For this reason, in recent years the Yerevan Municipality [www.ncsd.am] initiated a number of programs designed for improvement of condition of the city's green belt. One of such programs "The development of a target tree planting program for the city of Yerevan" was implemented as a complex research by the staff of the Center for Ecological-Noosphere Studies NAS RA (CENS) and included determination of levels of heavy metal pollution of Yerevan soils, localization of major traffic-induced emissions in Yerevan distrcits, a study of functional zonation and assessment of condition of plants growing in public areas such as streets, parks and squares, a study of metal accumulation potential and gas-and dust tolerance in different species, and mapping of final results with help of the ArcGIS information system. Then based on the obtained geochemical data and according to pollution levels, strongly, moderately and weakly polluted sites were isolated and ecologically tolerant plant species selected for each street, park and square. Proper implementation of the project results helps both establish and enlarge the Yerevan greening network so essential to the city and ensure longevity and durability of street and park species. Besides, researches of urban plants have a very important applied value as such species are both effective indicators in assessment of environmental pollution levels and economically efficient phytofilters for ambient air cleaning. Also, it is worth to mention that the staff of Biochemistry Department CENS has already implemented a lot of studies covering ecological tolerance of plants and their sanitary and hygienic properties. So, urban greening should be implemented based on functions of plants (target greening)and through creation of a target greening net (Book of statistical data, 2009-2011; Publ.: Center for Ecological-Noosphere Studies NAS RA, 2007-2008). Target greening takes into account both ecological problems and those emerged in the system of greening. In order to assure sustainable urban development, management of the above mentioned problems requires development of novel approaches.

In the frames of this research we studied species composition and condition of basic tree species growing in 10 parks and 20 streets of Yerevan. Based on the level and character of environmental pollution, condition and ecological tolerance of plants were studied and leaf sampling done. Wholly, 200 samples of leaves of the most widespread tree species (***Robinia pseudoacacia L., Fraxinus excelsior L., Populus alba L., Morus alba L., Vitis vinifera L., Ulmus pumila L., Ulmus leaves, Platanus acerifolia, Platanus orientalis, Querqus robur, Acer negundo, Alianthus altissima,Thuja occidentalis e.c***) were collected in the mid of vegetation period (July-August) 2007 from 105 sampling points scattered all over the city. The collected samples were treated (washed, chopped into small pieces and dying at a room temperature) by the accepted methods at the Central Analytical Laboratory CENS and then analyzed for heavy metal contents (Cu, Pb, Mn, Mo, Ni, Zn) through the atomic absorption method (AAnalyst 800, Perkin Elmer, US) consistent with ISO-8288, ISO-5666, ISO-11696 standards. A qualitative assessment of heavy metals in plants was done through a comparative analysis between actual and background concentrations. Background concentration values were taken from earlier researches. For studying heavy metal uptake by and accumulation in plants we used the coefficient of man-made concentration (Cc) and a summary concentration index (SCI). Finally, a relevant database was compiled and with help of ArcView software schematic maps produced which reflect the sampling points and data obtained (Publ.: Center for Ecological-Noosphere Studies NAS RA, 2007-2008; Hovhannisyan, H., 2015).

On the other side, the law "About ecological education and ecological culture" states that "To live favorable environment in the Republic of Armenia human constitutional right and a crucial task for the purpose of ensuring the protection of the natural ecological environment the implementation of each of the constitutional duties of citizens requires a high ecological culture, which is obtained during continuous environmental education" [http://www.arlis.am]: So, ecological education is regarded as a tool for reducing the number of ecological problems the city is facing today.

Ecological education can be conveyed in combination with appropriate researches, public awareness and involvement of the community. This all will finally bring to more active implementation of complex measures and more active involvement of the community and improvement of public awareness. In this respect urban greening as one of scientifically sound methods of sustainable development may be regarded as a means of ecological education and ecological culture. Ultimately, implementation of a complex concept of sustainable development is possible only if using education as a powerful tool.

In Armenia ecological education is a constituent of the national educational system and includes different levels: preschool, primary, secondary, college, higher and post-graduate education. Data collected through years about students, awareness of nature management programs and degree of involvement show the advance of students in acquiring more knowledge and skills in sustainable nature management and nature use that helps shape the so-called ecological outlook.

Ecological education is a scope of activities aimed at public ecological awareness and finally creation of ecologically safe and healthy environment for the population. Since 2000 a number of national and international programs have been implemented in the system of preschool and secondary nature management education, which are aimed at preservation of Armenia's nature and promotion of her natural and cultural legacy. Secondary education programs include the following nature management topics under a UN "Education for Sustainable Development" program: biological and landscape diversity, environmental conservation, ecosystems, natural resources management, climate change. However, the list of these topics may be added by urban greening so that the students could actively participate in practical works. Similar practice is done in some schools which -when organizing ecological education-pay particular attention to creation of teaching and learning environment, for instance, creation of "educational gardens" in schools where schoolchildren are given an opportunity to practically apply theoretical skills they acquire in looking after plants. Another example is the practice of using Armenia's reserves as an open-air lab for students. To fully apply ecological education, teaching and ecological trips are very important to learn more about the homeland, which also help practically use the gained theoretical knowledge. So, ecological education can help form abilities and skills of carefulness in students towards environment. According to Iakob Gogebashvili, the main goal of knowing the nature is "developing a sympathy for the nature in a youngster, making him love the nature" (The Door of Nature) foreword to the1st edition). A student while acquainting with interactions between a man and the nature, learns of ways the environment impacts human life and vv. environmental changes caused by a man. Acquaints with a diversity of natural resources, ways of their rational use and methods of proper utilization of household refuse.

So, ecological education is delivery of ecological knowledge, nature management skills and nature protection abilities, moral qualities through practical skills to younger generations. This all shapes a responsible attitude to the nature, ecological thinking, culture, the morality in students. It is also topical to hold teacher training courses covering issues of ecology, environmental protection and sustainable development. So, the nature management aspect of sustainable development is of considerable importance, which places a special emphasis on both academic research and proper dissemination of obtained results to different groups in the population.

Our studies have indicated that for creating a sustainable target urban greening system it is necessary to assess ecological status of the site, develop and introduce an assortment of ecologically tolerant species having good phytofilytation properties. Based on topicality of ecological issues associated with ecological problems included in the concept of sustainable development it is necessary to develop a new approach of greening strategy which would be based on researches. Greening programs accompanied by ecological education can only lead to desirable results and contribute to preservation of the planet Earth. Based on topicality of ecological problems in the concept of sustainable development it is essential to develop novel approaches to greening to underpin academic researches with simultaneous inclusion of teaching and educational elements. It is recommended that when developing analogous programs in the future, two factors should be taken into consideration: awareness of different community groups and their involvement.

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