Proceedings

of the 7th International Conference on Research in Didactics of the Sciences

DidSci 2016

June 29th – July 1st, 2016

Pedagogical University of Cracow, Institute of Biology,
Department of Education of Natural Sciences
Kraków 2016

Proceedings

of the 7th International Conference on Research in Didactics of the Sciences

DidSci 2016

June 29th – July 1st, 2016

Editors: Paweł Cieśla, Wioleta Kopek-Putała, Anna Baprowska

Pedagogical University of Cracow, Institute of Biology,
Department of Education of Natural Sciences
Kraków 2016

Editors:
Paweł Cieśla, Wioleta Kopek-Putała, Anna Baprowska

7th International Conference on Research in Didactics of the Sciences, DidSci 2016, was organized by Department of Education of Natural Sciences, Faculty of Geography and Biology, Pedagogical University, Kraków, Poland. The conference was held from June 29th trough July the 1st 2016 in Kraków, Poland

Proceedings were reviewed
by the Members of the Scientific Committee

Typset:
Paweł Cieśla

Cover:
Ewelina Kobylańska

ISBN 978-83-8084-037-9

DidSci 2016 Scientific Committee

Chair of the Scientific Committee

Hana Čtrnáctová – the Czech Republic

Members (in alphabetical order)

Agnaldo Arroio – Brazil

Martin Bilek – the Czech Republic

Liberato Cardelini – Italy

Paweł Cieśla – Poland

Hanna Gulińska – Poland

Vasil Hadzhiiliev – Bulgaria

Lubomir Held – Slovakia

Ryszard Maciej Janiuk – Poland

Gayane Nersisyan – the Republic of Armenia

Grzegorz Karwasz – Poland

Jarmila Kmetova – Slovakia

Vincentas Lamanauskas - Lithuania

Małgorzata Nodzyńska – Poland

Henryk Noga – Poland

Wiktor Osuch – Poland

Katarzyna Potyrała – Poland

Miroslav Prokša – Slovakia

Alicja Walosik – Poland

How Self-Directed Learners Learn Science

Meryem Nur Aydede Yalçin

Niğde Üniversity, Faculty of Education, Department of Science Education, Nigde/Turkey

Introduction

Today, many countries are questioning their current education systems. The reason for this is that it has been realized that traditional education systems are no longer considered to be efficient and societies do not need stereotyped brains but curriculums that educate people who think analytically and critically, and solve problems. Therefore, curriculums developed today aim at students' learning not by sitting quietly or hearing only the information transferred to them but by seeing, touching, analyzing, speaking and sharing, in other words they aim at active learning.

In active learning process, students have the opportunity to take responsibility for managing their own learning processes. Students must set their own learning goals, plan and evaluate their levels in active learning. This allows students to continue learning after completing their education at schools by making lifelong learning and self-directed learning, currently one of the important skills in our society (Lunenberg, Volman, 1999; Euge`ne 2006).

Self-directed learning skills are defined as students' taking responsibility for their own learning process. Students with self-directed learning skills find appropriate resources for their learning goals and decide their learning and assessment methods by themselves (Russell, Comello and Wright, 2007).

2013 Science course curriculum in Turkey is based on an inquiry-based learning approach. In the 2013 Science course curriculum, it is intended to create a classroom environment in which students are responsible for their own learning, active participation is ensured in the learning process, and activities that allow constructing information in mind are developed. This change occurring in Turkish education system was the starting point of this study. Hence, in this study, unstructured interviews were conducted with 37 sixth grade students who were studying at a state secondary school and had good level self-directed learning skills. With the findings obtained from this study, teachers will guide students to orient them towards behaviors that will help them acquire self-directed learning skills in classroom environment.

Method

Case study approach which is one of the qualitative research method was used in this study. The research was conducted in the 2015-2016 academic year.

Population and Sample

Self-directed learning skill scale for science and technology course was used in the study to determine which students had good level self-directed learning skills. The scale developed by Aydede and Kesercioğlu (2009) and consists of two factors. These factors include "Planning Self-directed Learning " (α = 91), and "Self-Confidence in Self-directed Learning" (α = 78) ". The reliability coefficient (Cronbach Alpha) regarding the whole scale was .86. The other data collection tool was unstructured interviews. For this reason, self-directed learning skills scale for Science and Technology course developed by Aydede and Kesercioğlu (2009) applied to 78 6th grade student studying at a state school in Nigde/Tukey. After the descriptive analysis results of self-directed learning scale, the research group of the study consisted of 37 sixth grade students with high level (higher then 93) self-directed learning skills at a state school in the city centre of Nigde according to purposeful sampling method. Related results about the descriptive analysis results were presented in Table 1.

Table 1. 6th grade students' self directed-learning scale points' aritmatical average

Students	$\bar{X}$	Students	$\bar{X}$	Students	$\bar{X}$	Students	$\bar{X}$		
S1	121,00	S9	109,00	S17	102,00	S24	97,00	S31	95,00
S2	121,00	S10	107,00	S18	102,00	S25	97,00	S32	95,00
S3	115,00	S11	106,00	S19	101,00	S26	97,00	S33	95,00
S4	115,00	S12	105,00	S20	101,00	S27	96,00	S34	94,00
S5	114,00	S13	105,00	S21	100,00	S28	96,00	S35	94,00
S6	114,00	S14	104,00	S22	99,00	S29	96,00	S36	93,00
S7	110,00	S15	104,00	S23	99,00	S30	95,00	S37	93,00
S8	110,00	S16	103,00						

While researching the learning ways of 37 6th grade students who had good level self-directed learning skills, unstructured interview technique was used as a second d**ata collection tool.** According to Cohen, Manion and Morrison (2007), interview technique is used to collect rich and extensive amount of information in qualitative research in which the working group is often kept small. The interviews conducted during the research were generally carried out within the framework of the question, “how do you learn science? The interviews were recorded through a tape recorder. The analysis regarding the data was conducted after transferring the data recorded on the tape recorder to a computer environment.

Data analysis

Descriptive analysis and content analysis techniques were used to analyze the data. Frequency analysis, one of the descriptive analysis methods, was performed for the analysis of the data obtained from the self-directed learning skills scale applied to 78 sixth grade students. In the analysis of the interview data conducted with 37 students with good level self-directed learning skills, content analysis method was used.

Before the content analysis of the qualitative data, interview results were transferred to a computer software. Then, determined codes were determined about the students learning ways towards science course. The reliability of the study was calculated by the formula that Miles and Huberman (1994) proposed for qualitative research. The interview data transferred to a computer were divided into categories by being coded by two different faculty members. The reliability was found to be .88 by calculating the items about which the two different researchers reached an agreement and had disagreement. The fact that the reliability was over .70 is an indicator that this study is reliable.

Findings

As a result of the detailed interviews performed with 37 sixth grade students, it was found out that the 37 students who got good scores from the self-directed learning skills scale used these learning ways while learning science; learning by using the internet (f = 31), learning by writing (f = 21), learning with the help of the family (f = 20), learning from textbooks (f = 16), learning by doing research (f = 17), learning by studying from books apart from textbooks (f = 15), learning from class notes (f = 14), learning by solving test (f = 13), memorizing (f = 12), learning with the help of teachers (f = 12), learning by summarizing the subject (f = 7), learning by getting help from friends (F = 4), learning by watching videos (f = 2), learning from what the teacher has told during the course (f = 2), learning through experiments (f = 1). The diagram about these finding is presented at Figure. 1.

Totally 23 of the students who participated in the interview stated that they learnt better through group work. The students learning with a group were also the ones with higher grade point averages. Out of the 23 students pointing out that they learnt better through group work, 21 of them stated that they learnt mostly by using the internet during the group work and 14 of them indicated that they learnt by getting help from their families.

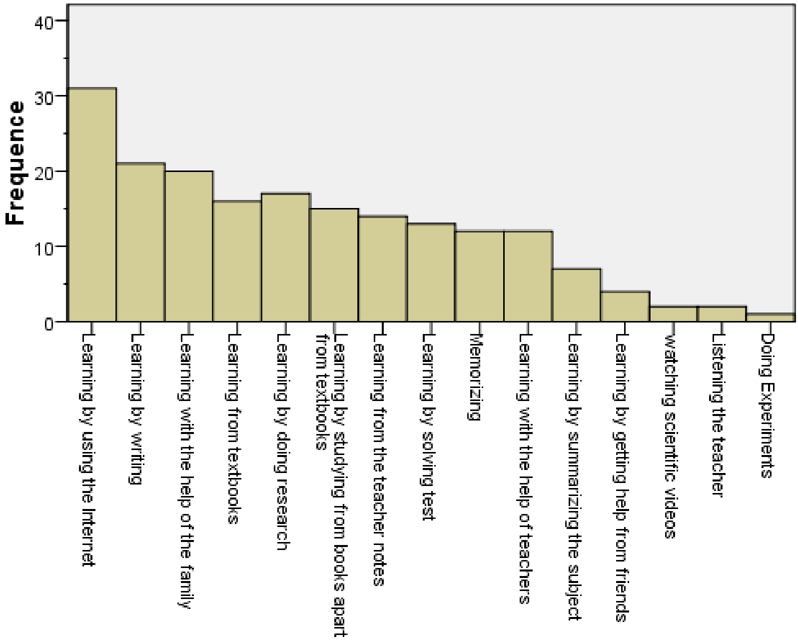


Figure 1. Content analysis and descriptive analysis results of unstructured analysis results.

Totally 14 of the students participating in the study preferred individual learning. The students who preferred individual learning were the ones with relatively lower grades in the science course. It was detected that eight of the 14 students who preferred individual learning learnt by memorizing and 10 of them learnt by using the internet.

Results and Conclusions

In conclusion, the learning ways that students with self-directed learning skills used most frequently was learning by doing research on the internet. For the second most frequent one, it was found out that students learnt by writing the information they obtained. In addition, it was also revealed that the students who scored high on the self-directed learning skills scale for science and technology course used more than one way while learning science. For instance, they received help both from their teachers and parents and also did research while learning any subject. In the present study carried out with 37 students who had self-directed learning skills, it was found that 12 of these 37 students received help from the teacher and 25 of them used some learning ways apart from getting help from the teacher (the internet, course book, etc.) during their learning process. The studies showing similarities with the results of this study in Turkey were also examined, such as Belge-Can and Boz (2012). As a result of the study in which the Belge-Can and Boz (2012) examined elementary school students' approaches to learn science, the researchers determined that as students' ages increased, their meaningful learning approaches decreased, but the students implemented meaningful learning more compared to rote-based learning at all grade levels. In addition, as a result of Çoban and Ergin's (2008) study in which the researchers examined primary school students' learning approaches, it was revealed that the students had both deep learning (meaningful learning) and surface learning (memorizing) approaches.

References

Aydede, M. N**.,** & Kesercioğlu, T. (2009). Developing self direct learning scale toward science and technology course. *Journal of Çukurova Üniversity*, Faculty of Education 36, pp. 53-61.

Belge-Can, H., & Boz, Y. (2012). Yaş ve cinsiyetin ilköğretim öğrencilerinin öğrenme yaklaşımlarına etkisi, X. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, 27-30 Haziran, Niğde. Dersini Öğrenme.

Cohen, L., Manıon, L., & Morrıson, K. (2000). Research methods in education. (5.Baskı). London: Routledge & Falmer Pres.

Euge`ne, C. (2006). How To Teach At The University Level Through An Active Learning Approach? Consequences For Teaching Basic Electrical Measurements. Measurement. 39(10). pp. 936-946.

Lunenberg, M. L. & ve Volman. M. (1999). Active Learning: Views And Actions Of Students And Teachers İn Basic Education. Teaching And Teacher Education.15. pp. 431-445.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis: An expanded sourcebook. California: SAGE Publications.

Russell, A.T., Comello, R. J., & Wright, D. E. (2007). Teaching Strategies Promoting Active Learning İn Healthcare Education. Education And Homan Development. 1(1).

Ünal-Çoban, G. & Ergin, Ö. (2008). The instrument for determining the views of primary school students about scientific knowledge. Elementary Education Online, 7(3), pp. 706–716.

Knowledge on Health Protection in the Use of Information and Communication Technologies (ICTs) - A Condition of The Students‘ Motivation and Optimization of Physical Curriculum

Zuzana Balazsiova

Slovak Republic
zuzana.balazsiova@fmed.uniba.sk.com

The context and purpose of the framework

Young people are increasingly using computers, cell phones, GPS and other ICTs. They are motivated by quick navigation, quick contact, quickly available information... They do not become aware of the negative impacts of these facilities on their health during their long-term use without acceptance of the rules of occupational hygiene. Factors that cause health problems called Computer Vision Syndrome (CVS) are mainly: monitor blinking, poor lighting, incorrect distance of the body / eyes from the monitor, incorrectly (although comfortably) posture when sitting... These factors cause irritation of eyes, headaches, back and wrist pain. (Montagni, 2015) Gary Heiting and Larry K Wan (2016) recommend: to use proper lighting, to minimize glare, to adjust computer display settings, to blink more often, to exercise eyes, to take frequent breaks, to modify workstation, to replace contact lens for computer eyewear. Heiting (2015) suggested other 10 types of computer ergonomics for healthy vision. Health safety during work with computer is not emphasised in teaching process at school. Pupils and students are poorly informed about possible negative health effects.

The aim of our study was to determine the students´ knowledge level on health protection in to use ICTs at the beginning of university study.

Methods

The research sample included 57 boys and 128 girls - students of the 1st year of medical study. Their average age was (19.68 ± 1.5) years. Age boys and girls did not differ significantly. The oldest participant was 31 years, the youngest 18 years old. Original questionnaire was used. Respondents answered in written form to the question: *“Please list the principles of protecting your health and safety during the work on your computers and other electronic devices.“* All responses were categorized according to the formulated principle: a) vision and hearing protection and ergonomics, b) safety of working with electricity, c) software and hardware protection, d) occupational hygiene and fire protection. Quantity and quality of respondent´s answers were analysed.

Results

The results of our research showed an alarming fact that nearly one third of the 185 students the first year of medicine did not recognize any principle health at work with a computer or other electronic devices. Only 1% of students reported five expressions that were focused on health protection.

Vision, hearing protection and ergonomics

According to our expectations, the most of students had knowledge of the field of vision, hearing and ergonomics. Often is presented the view that the health protection is related to the time spent at the computer, less frequently was mentioned good posture - back up straight, support the hands was rarely. The difference of opinion was independent of the gender of the individual.

Safety of working with electricity

Almost half of the evaluated expressions (without significantly affecting gender) in this category was aimed at controlling connecting the device or computer to the mains. Priorities in the safety at work with electrical devices were different according gender in two areas: girls prefer to turn off the equipment during storms and at night, while boys prefer to prevent contact of device with liquids.

Software and hardware protection

12% of students mentioned „protecting hardware and software". We think that contentions of students were focused to protect sensitive and personal data from loss (protection hardware) or from undesired leakage and subsequent misuse (software protection). Data protection is equally important for men and women. No consumption of food and beverages during work with computer, clearly dominated in the protection of hardware. Occupational hygiene and fire protection

This group covers a small part of all expressions. They are general rules for safety and health at work in the school, which are read usually to students – do not run, respect discipline on work place, safe working environment, protection against fire, electrical fire is not to extinguish with water… We assume that some of the expressions are resulted of students´ own experiences – protecting computer from overheating, cooling of computer, do not work when you are tired... We would like emphasize the expression of „protection of the body against overheating from laptop". It is striking, that only 2 girls from 185 students wrote this expression.

Conclusions and implications

Despite the fact, that students use not only computers, but cell phones and other ICTs every day, a large part of them haven´t knowledge about their health and safety. We consider that the current issue of safety at work with computers and ICTs should be included in education at all school levels. Attention must be paid young children (kindergarten, primary school) - in particular to the time spent at the computer, how is used ICT equipment, ergonomic aspects...Wrong habits acquired at a young age are hard to remove later. Creating projects appears to be a suitable method for teaching this topic at the secondary school. (Kráľová, 2010, Nodzyńska, 2015) It could be taught in the human biology (body posture) and physics (impact of electromagnetic wave on human body). All students should be educated on this issue after entering on university studies.

Contribution was supported by GP KEGA Ministry of Education, Science, Research and Sport of the Slovak Republic № 003UK-4/2016.

References

Heiting, G. OD. (2015). *Computer Ergonomics for Healthy Vision*. [Page updated January 2015] Retrieved 2016-06-23, from http://www.allaboutvision.com/cvs/ergonomics.htm.

Heiting, G. OD & Wan, K. L. OD. (2016). *Computer Eye Strain: 10 Steps for Relief.* Online [Page updated June 20, 2016] Retrieved 2016-06-23, from http://www.allaboutvision.com/cvs/irritated.htm.

Kráľová, E. (2010). Promotion of learning process by projects´. *Abstract book The 4th International Conference Research in Didactics of the Sciences Kraków.* Pedagogical University of Kraków, Kraków 2010. p. 63-64.

Montagni I, et al. (2015). Screen time exposure and reporting of headaches in young adults: A cross-sectional study. *Cephalalgia*. 2015 Dec 2. pii: 0333102415620286. [Epub ahead of print]

Nodzyńska, M. (2015). Metoda projektów czy PBL? In: Nodzyńska, M. and Kopek-Putała, W. (eds.) *Co w dydaktykach nauk przyrodniczych ocalić od zapomnienia?* (100-112) Uniwersytet Pedagogiczny w Krakowie, Kraków.

The Influence of Organisational Conditions on Effectiveness of Lower Secondary Chemistry Education

Anna Baprowska, Martin Bilek

*University of Hradec Králové, Faculty of Science,
Hradec Králové, The Czech Republic, a.baprowska@gmail.com*

Introduction

Chemistry teachers complain about the lack of time to implement all planned lesson tasks and too few hours of chemistry at the school curriculum, during which students could assimilate the issues contained in the core curriculum. In teachers' opinion (...) this is one of the causes of learning difficulties. It is believed that the use of the tools used in economics for time planning to plan the lessons and organization of learning process will lead to achieving better results of teaching and learning. Educational processes must be organized in a manner conducive to learning. Students should know the rules of the planning the time in order to make his learning the most effective. This ability is essential to learning in all subjects, however due to the specific structure of chemistry as a science it will be especially useful in this subject. A student starting to learn chemistry must possess certain basic knowledge, that is fundamental to climbing on the various levels of education, without which the success will be impossible. The proper planning of the learning process requires constant monitoring of the actual state of the students' knowledge. The new teaching content shouldn't be introduced until the students have mastered the basics. It has been observed when working with students with difficulties in learning chemistry that the actions of the teacher specifying the exact time, place and manner of learning (appropriate planning of study time) allows pupil for the mastery of knowledge at a satisfactory level.

It has been observed that when working with a pupil with diagnosed difficulties in chemistry learning that the actions of the teacher specifying the exact time, place and manner of learning (adequate planning study time) allows the mastery of knowledge at a satisfactory level. Kamińska-Ostęp (2011) says that effects of chemical education depend on its organization.The proper of organization of education should enable pupils multidirectional activity and allow to respect individual pupils' individual features in community of learners. Developing educational situations in which teacher is able to teach in small groups or individually should have effect on increasing of effectiveness of education.

There are many tools that can be used for planning purposes. For example platforms for distant learning can be placed among them. The use of e-learning platforms for educational purposes is widely described in a literature

(Skrzydlewski, Kuźmicz & Michalak, 2006), however one thing should be highlighted - an application of such platform to management of learning. A good example of widespread use can be a Moodle platform. The main role of the platform is to enable distant learning and support teaching in the classroom. However it allows to plan pupil's activities and teach him to work regularly resolving tasks planned by a teacher. Each pupil can have designed his own course with activities adjusted to his special needs, especially that even smart pupils have troubles with planning their time. The best way is cooperation pupil - teacher and development of time scheduled individual learning program or so called „work calendar". The time periods can be different, however practice shows that the best results are achieved with weekly periods. In such periods there is very often verification of student's progress. In contrast in long-term plans there are troubles with keeping pupils highly motivated.

The research

It was assumed that students with learning difficulties should have the weekly monitored work calendar set. Every day each student should be practicing a particular skill, which makes him a trouble. Tasks for him must be short and should last no longer than 15 minutes a day, otherwise they discourage the student to work. In addition, the students have also other school subjects with which pupils often cannot cope with.The research were carried out. In the research the learning of writing chemical formulas and ability of their interpretation have been used. There were two pupils who took part in the research. One with learning difficulties and the other smart and talented. The research lasted for six months. The gifted pupil had his learning programme set for whole sixth months period and evaluation have been done monthly. He could choose the way of learning by his own. In contrast, the pupil with learning difficulties had weekly monitored plan and his day was thoroughly planned. He had to perform specific tasks. Basing on his achievements the teacher planned his works for further week.

Results

The gifted pupil had achieved excellent results. He has achieved the title of laureate of the regional competition in chemistry. A year before the same pupil was to realise the same plan, however he abandoned it and he has not achieved any prize.

The pupil with difficulties achieved promotion to the next year and, according to his parents it was for him a great achievement.

Conclusions

The method works effectively under a few conditions: In planning of work time the following factors should be taken into account:

– talents and individual needs of a pupil;

– the way of learning;

– pupil's motivation - if his motivation is to weak the teacher should encourage him and convince that his works make sense and will bring positive results. For this purpose the teacher can use his own successes or defeats or achievements of other pupils.

– in case of pupils with learning difficulties the cooperation with pupil's parents should be established.

Acknowledgements

The article is supported by Specific Research Project of the Faculty of Science, University of Hradec Kralove, Czech Republic Nr. 2118/2016

References

Skrzydlewski, W., Kuźmicz, K., & Michalak, A. (2006). Wybrane aspekty e-learningu In *Media a edukacja – od nowych technik nauczania do edukacji wirtualnej*. PTTiME Poznań: Poland.

Kamińska-Ostęp, A. (2011). Indywidualizacja w nauczaniu chemii - wyzwaniem dla nauczycieli? in: M. Nodzyńska Ed. *Metody motywacyjne w nauczaniu przedmiotów przyrodniczych* Pedagogical University of Cracow, Kraków: Poland.

Bridging the Gap Between Macroscopic and Microscopic Comprehension of the Mole

Andrzej Barański[1], Tomasz Sawoszczuk[2]

[1]*Faculty of Chemistry, Jagiellonian University, Kraków, PL*
baranski@chemia.uj.edu.pl
[2]*Uniwersytet Ekonomiczny w Krakowie*

The base quantity "amount of substance" and its base unit "the mole" are the subject of an endless debate. The title of the review article, by Furio *et al.*(Furio, 2000), based on more than hundred references, has been alarming: *Difficulties in teaching the concepts of 'amount of substance' and 'mole'*. Leonard (2016) has enhanced a dramaturgy. The title of his recent paper sounds: *Why is 'amount of substance' so poorly understood ? The mysterious Avogadro constant is the culprit !* Note, This paper was published more than half century after 'amount of substance' had been established as the base quantity in 1971. Finally let me quote the sentence by Tulberg (1994) as seen in the article by Fang *et al.* (2014) ……*a great proportion of the students were confused about when it is appropriate or beneficial to use which definition*.....[of the mole]. The above literature remarks enable to fix the scope of this paper.

This publication is focused on the two fundamental problems related to stoichiometry teaching. These are: (i) a choice of an adequate name for the base quantity of which the mole is the base unit (ii) the significance of the three commonly used definitions of the mole and their compatibility. The last issue stems also from Barański (2014).

The current SI definition of the mole and Avogadro's number

The most essential part of the current SI definition of mole, adopted in 1971, reads: *The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilograms of carbon-12* (BIPM, 2006). Dividing 12 grams (mass of the mole of C-12 atoms) by 12 daltons (the mass of the C-12 atom) yields the number of atoms in the mole commonly known as Avogadro's number (N_{Avo})[1] Hence N_{Avo} = g/Da The ratio of two mass standards can be found only by an experiment. Thus Avogadro's number is experimentally, inexactly known, ratio gram/dalton. The experimental determination of N_{Avo} is equivalent to expressing dalton in grams. Then both sides of the equation N_{Avo} = g/Da are dimensionless.

1 Symbol N_{Avo} for Avogadro's number has been proposed by Leonard (Leonard, 2016). Unfortunately, Avogadro's number is denoted as N_A, in the abstracts book of DidSci 2016 conference (see p.9).

Amount of substance and microscopic definition of the mole

Firstly, some general remarks are helpful. As is commonly known, the base quantities of the SI system have been chosen by convention (BIPM, 2006, p.103). They are so familiar that the definitions have not been needed. (Mills, 2016) Let me hypothesise that our obvious, intuitive comprehension of them is an implication of the evolution of mankind. *Distance, time, mass, temperature* and *luminosity* had to be taken into account by hunters, whose success was needed for survival during the pre-agriculture age. One should be aware that prides of lions and packs of wolves were hunting earlier than our ancestors. *The electric current*, as a quantity, is similar to the water current. Examples of latter, rivers and creeks, were observed by our ancestors over millions of years. *Amount of substance*, claimed widely as difficult to understand, is the only exception among the base quantities listed above. There were no reasons for evolution to shape our brains for intuitive understanding of this. Therefore *amount of substance* should be replaced by another name. Note, the *collection of entities* (Barański, 2012) or *aggregate of entities* (Leonard, 2007) would be easy to accept, not only by contemporary students but even by our hunting ancestors. Twenty killed birds or gathered fruits yielded more food for the hunter's family than three ones.

Let me turn to metrology. As recommended by Leonard (2016), there is a need to establish the "entity", symbol ent, as a natural atomic-scale unit of "amount of substance". It is *the smallest possible amount of any substance*. A molecule or an atom is an example. If "entity" unit is established and amount of substance is replaced by collection of entities the following definition of the mole will be easy to comprehend. The mole is… *Avogadro number of entities, where the Avogadro number is gram-to-dalton mass-unit ratio* (Leonard, 2014)

Note, the above definition can be considered as the microscopic definition of the mole.

Equivalence of microscopic and macroscopic definition of the mole.

In a laboratory practice where for analytical or preparative purposes substances are weighed frequently the macroscopic definition of the mole is applicable. The quote from the Zumdahl's textbook (1997) can be considered as the said definition: *The mole is defined such that a sample of a natural element with a mass equal to the element's atomic mass expressed in grams contains 1 mole of atoms.* This definition can be obviously and easily extended to compounds.

Our aim is to show the equivalence of the microscopic and the macroscopic definition of the mole. The calculation of the mass of one mole of a substance is the simplest way to do this, as seen below.

$$m_{1\,mol\,Y} = N_{Avo} \times m_Y = (m_Y/\mathrm{Da}) \times (N_{Avo} \times \mathrm{Da}) = M_Y \times 1\ \mathrm{gram} = M_Y \times \mathrm{gram} \quad (1)$$

where:

m_Y is the average atomic or molecular mass of substance Y, weighed by isotopic abundance, expressed in grams.

$m_{1\,mol\,Y}$ is the mass of one mole of substance Y in grams.

$M_Y = m_Y/\mathrm{Da}$ is the relative dimensionless atomic or molecular mass of Y. Of course

dalton is expressed in grams.

The first equation $m_{1\,mol\,Y} = N_{Avo} \times m_Y$ describes the microscopic definition of the mole. The final equation $\mathrm{m}_{1\,mol\,Y} = M_Y \times \mathrm{gram}$ describes the macroscopic definition. The bridging effect, emphasized by Fang *et al.* (Fang, 2014) and by the title of this publication too, has been proved obviously. Note, the equations (1) are equivalent to equations (2) of the paper (Baranski, 2014). I hope the presented approach to fundamentals of stoichiometry will be useful for teaching purposes.

References

Barański A. (2012). The Atomic Mass Unit, the Avogadro Constant, and the Mole. A Way to Understanding, *J. Chem. Educ.,* 89, 97-102.

Barański A. (2014). Comment on "Unpacking the Meaning of the Mole Concept for Secondary School Teachers and Students". *J Chem Educ* 91, 1098-1098.

BIPM (Bureau International des Poids et Measures) (2006), Le Système international d'unités,The International System of Units, (8th ed.) p. 114-115 http://www.bipm.org/utils/common/pdf/si_brochure_8.pdf (accessed July 2016).

Fang S-C., Hart C., & Clarke D. (2014). Unpacking the Meaning of the Mole Concept for Secondary School Teachers and Students. *J Chem Educ,* 91, 351-356.

Furió C., Azcona R., Guisasola J., & Ratcliffe M. (2000). Difficulties in teaching the concepts of 'amount of substance' and 'mole'Int. *J Sci Educ,* 22, 1285-1304.

Leonard B.P. (2007). The atomic-scale unit, entity: key to a direct and easily understood definition of the SI base unit for amount of substance. *Metrologia,* 44, 402-406.

Leonard B.P. (2014). The mole is an Avogadro number of entities, the macroscopic unit for chemical amount. *Accred Qual Assur*, 9, 203-220.

Leonard B.P. (2016). *Why is ' amount of substance' so poorly understood ? The mysterious Avogadro constant is the culprit ! Accred Qual Assur*, 21, 231-236

Mills I. (2016). On the units radian and cycle for the quantity plane angle *Metrologia*, 53, 991- 997.

Tulberg A., Strömdahl H., & Lybeck L. (1994). Students' conceptions of 1 Mole and Educators' Conceptions of How They Teach "the Mole". *Int J Sci Educ,* 16(2), 145-156 .

Zumdahl S.S. (1997). *Chemistry* 4th ed. Houghton Mifflin Co., Boston, New York p. 84.

Numerical Simulations Inclined Throw with Regard the Air Resistance

Slavko Buček

OSNOVNA ŠOLA I Murska Sobota, Slovenia
slavko.bucek@gmail.com

Introduction

Free fall is a type of motion in which the only force acting upon an object is gravity. Objects that are said to be undergoing free fall, are not encountering a significant force of air resistance. They are falling only under the influence of gravity. Under such conditions, all objects will fall with same rate of acceleration, regardless of their mass. A feather and stone will fall with equal velocity in a vacuum. In presence of air, we have other conditions and therefore unequal velocities. It is easy to express these dependences with hyperbolic functions. However, in secondary and high schools these functions are unknown, very hard for use and to understand them. We found out other tools to solve this task. To avoid complex mathematical functions, we have been solving it with numerical methods.

Velocity of a falling object with air resistance is changing, and therefore air resistance force (ARF) (drag) is changing too. ARF versus velocity is square dependent (Parker, 1977). After a sufficiently small period of time *dt* we have new velocity v_1 and therefore new ARF. When an object falls through air, the ARF is increasing with square and therefore decreasing its acceleration a. Furthermore, after certain period of time, velocity reaches terminal velocity v_t.

Methods are helpful for a moving object through the air with arbitrary initial velocity and slope. We have researched an inclined throw and trajectory of projectile motion. Total velocity, acceleration and trajectory were found by adding the vertical component of the velocity and the horizontal component of the velocity. Trajectories are presented with graphs (Warburton, Wang, & Burgdörfer, 2010).

Theoretical approach

For an inclined throw in the vacuum initial velocity v_0 and the launch angle α with respect the horizontal are important. v_0 consists of horizontal $v_x = v_0 cos\alpha$ and vertical $v_y = v_0 sin - gt$ components. Let (x,y) be position in plane of projectile after time period *t*. Thus

$$x = v_0 t\ cos\alpha \text{ and } y = v_0 sin\alpha - \frac{gt^2}{2}.$$

Trajectory of motion by ignoring air resistance is parabola (Fig. 1). The maximal range in x direction is by angle of incline $\alpha = 45^\circ$.

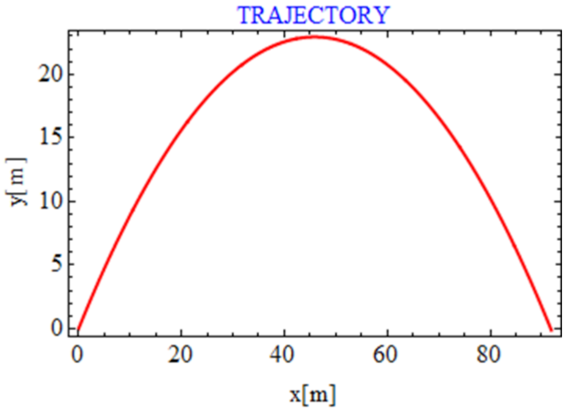


Figure 1. Trajectory of motion a projectile in the absence of air. The curve is parabola and is symmetric.

Numerical simulations

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

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

In presence of air, trajectory of motion for an inclined throw is not a symmetric curve.

In Fig. 2 we see trajectories for initial velocity $v_0 = 20\ m/s$ for different angles of the incline.

Conclusion

In the future it will be interesting to continue researching maximal distance in the x-direction and its dependence from other parameters.

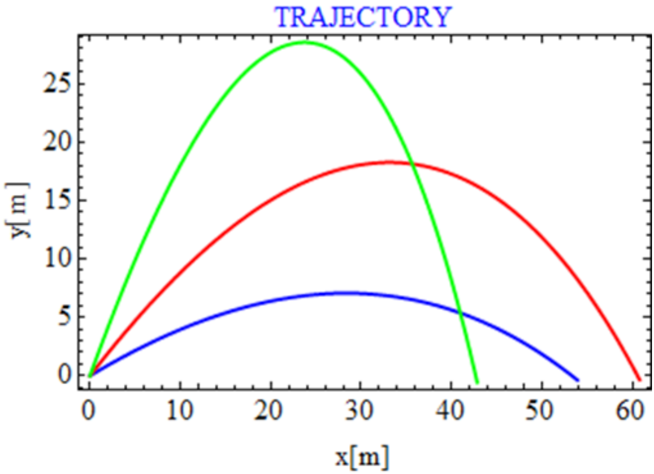


Figure 2. Trajectories of motion with three different angle of the incline (25°, 45°, 65 °), and $v_0 = 20\ m/s$.

References

Parker G. W. (1977). Projectile motion with air resistance quadratic in the speed. *American Journal of Physics*, 7, pp. 606-610.

Warburton, R. D. H., Wang, J., Burgdörfer (2010). Analytic Approximations of Projectile Motion with Quadratic Air Resistance. *J. Service Science & Management*, 3, pp. 98 -105.

The Effectiveness of Different Approaches to Excursions in Waterworks

Simona Čábelová, Martin Rusek

Czech Republic, simona.cabelova@gmail.com

The context and purpose of the framework

Museum pedagogics is currently a widely discussed topic, as evidenced by a large number of relevant articles available. The positive aspects of outdoor education are documented e.g. by the research of Broman & Simon (2014) or Piqueras et al. (2008).

The topic of water in Czech curriculum is broadly included in several fields within natural sciences. One of the often chosen possibilities in schools is the excursion to water treatment plant, which offers the connection of all different points of view.

The exhibition in water treatment plant in Podolí includes all aspects of water treatment from the Czech or Prague point of view. It offers the history of water treatment, information about soils of drinking water for Prague, water-technique used in history, modern approaches to inspect on the quality of water, processes of water purification etc. The exibition therefore offers opportunity to connect separated information about water and shows its importance for everyday life also to students. This is one of the importatnt aspects of outdoor education, which was found out by students as a factor increasing their attitudes toward science (Broman & Simon 2014; Lindner 2015, Sellmann & Bogner, 2012).

The authors of this paper got familiar with the programme in the water treatment and introduced several changes. The survey designed in order to evaluate the alternative approach followed these questions: 1. To what extent is contemporary conception of the exibition in Water treatment plant in Podolí effective? 2. Would problem-based approach improve the effectiveness of the exibition for elementary school excursions?

Methods

An alternative approach respecting modern educational approaches i.a. constructivism, student centred problem-based education was proposed opposed to the monologue-based approach used by the museum guide. Two groups of respondents, grade 9 students (age 14-15) elementary school in Prague, went on an excursion under different tutelage. Class 9A under a tour guide of the water treatment plant in Podolí, class 9B was guided by the authors of this article.

In accordance with the curriculum (Framework educational programmes) and expected of students' knowledge considered necessary by the authors of this study, a didactical test was compiled to test the students' knowledge.

Results

Based on the fact the samples are small, (N< 30) the data nomality test is not necessary and the t-test may be used. Nevertheless, Shapiro-Wilkov test was conducted. The zero hypothesis (the data do not have normal distribution) was not possible to reject on the 1% significance level. The data have normal distribution.

In order to compare the two student groups'results in the pretest, both t-test and Mann- Whitney test were used. Both the p-values (t-test p = 0,21; Mann-Whitney p = 0,36) as well as the Hays coefficient (1,7%) suggest, there is no statistically significant difference between the two groups in the pretest.

For the pretest-posttest difference, the pair t-test was used for dependent samples. The results are introduced in tab. 1.

Tab. 1 Pretest-posttest results comparison

	p-level t-test	Hays koeficient
Experimental group	*p=0,000*	64,56 %
Control group	*p=0,021*	12,43 %

For both the groups a statistical as well as objective significance were found between the results of pretest and posttest. From the objective significance point of view, it is possible to argue that the posttest results are influenced by 12% in the control group (9.A) and 65% in the experimental group (9.B). The differences are displayed by the quartile graphs (Fig. 1).

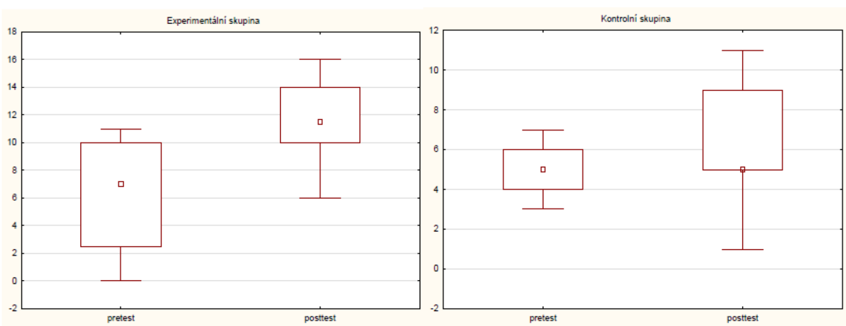


Figure 1. Experimental (left) and control (right) group pretest-posttest difference

In the control group, there was only a shift among respondents placed between the bottom and upper quartile. On the other hand, in case of the experimental group, a shift in the vertical line was recorded. This means the students in the experimental group have statistically significantly improved, students in the control group have not improved on the 1% significance level.

Conclusions and implications

According to the statistically significant improvement of the students in the experimental group, it is possible to conclude that the alternative conception of the excursion may be more effective than the original one. Further analysis of the results is needed nevertheless. There were particular questions the guide did not mention included in the didactical test. Also, several items in the test reveal other factors which intervene in the simple results interpretation.

In general, however, it is possible to state a change of the conception is more effective. A positive aspect of this work is also in cooperation with the water-treatment plant exposition managers. This initiative may therefore lead to an alteration in the ordinary museum programme and broader cooperation with the water-treatment plant in the educative efforts.

References

Broman, K, & Simon, S. (2014). Upper Secondary School Students' Choice And Their Ideas On How To Improve Chemistry Education. *International Journal of Science and Mathematics Education*, 13(6), pp. 1255-1278.

Lindner, M. (2015). Outdoor Projects in STEM: Results of Research on Students´ learning and motivation. *Project-Based Education in Science Education* (Vol. XII., pp. 21.-27.). Prague, Czech Republic: Charles University in Prague, Faculty of Education.

Piqueras, J., Karim, M., Edvall, S. & Edvall, H. (2008). The Practical Epistemologies in the Museum: A Study of Students' Learning in Encounters with Dioramas. *The Journal of Museum Education*, 33(2), pp. 153-164.

Sellmann, D., & Bogner F., X. (2012). Effects of a 1-day environmental education intervention on environmental attitudes and connectedness with nature. *European Journal of Psychology of Education*, 28. pp. 1–10.

Portrait of a Good Teacher

Marcin Chrzanowski, Maria Zachwatowicz

University of Warsaw, Faculty of Biology, Warsaw, Poland
m.chrzanowski@biol.uw.edu.pl, m.zachwatowicz@uw.edu.pl

Introduction and Aims

The issue of 'good teaching' has been approached internationally by a number of researchers in various ways (e.g. Brophy & Good 1986, James & Pollard 2011, Burns & Darling-Hammond 2014, Coe et al. 2014). The main aim of this study was to determine the most important characteristics that enable the teachers to be effective. We concentrated on the academic students' views because students were directly affected by good and bad teaching in the past. We addressed the following research questions: What characteristics are used by students to describe an effective teacher? Which characteristics are identified as the most important ones?

Methods

The undergraduate, graduate and postgraduate students (ISCED 5, ISCED 6) attending 'the teacher training module' at the Faculty of Biology (University of Warsaw) or registered to the course in 'Didactics of higher education' in the academic year of 2015/2016 were involved in this study.

Students were asked to write down five, most important qualities that good teachers possess. The BSc and MSc students were interviewed twice – at the start of their teacher training module (21 students) and then when they were finishing it (18 students), while the doctoral students were interviewed only once (26 students), in the beginning of the course.

All interviewed students were working toward their bachelor's, master's or doctoral degree in biological sciences, which means they were not majoring in education, however they were preparing themselves to obtain a license to teach biology and/or science in the primary school, gymnasium or secondary school or to gain qualifications to become an academic teacher.

Results

Our results show that 'good teachers' share at least a dozen of characteristics (Fig.1). We discovered some remarkable differences in the perceptions of the PhD students and BSc/MSc students (Fig.1). PhD students valued the most teacher's justice, openess, passion and good preparation. The teacher should possess a deep knowledge and be able to transmit it easily. For MSc/BSc students a teacher should be above all professional and competent, patient and understanding, committed and consequent and he should possess very good communication skills. Both of the groups rated the creativity and charisma of the teacher very high.

We discovered also many soft skills reported by both of the groups (however, indicated by less than 10% of respondents) (Fig. 2). The core categories reported by the BSc&MSc in the beginning and after the course remained stable.

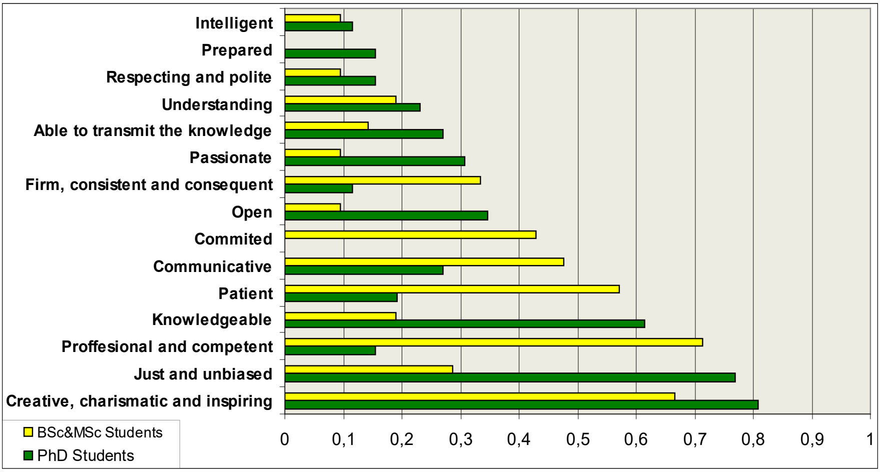


Figure. 1. The most important characteristics of a 'good teacher' as indicated by the BSc/MSc and PhD students.

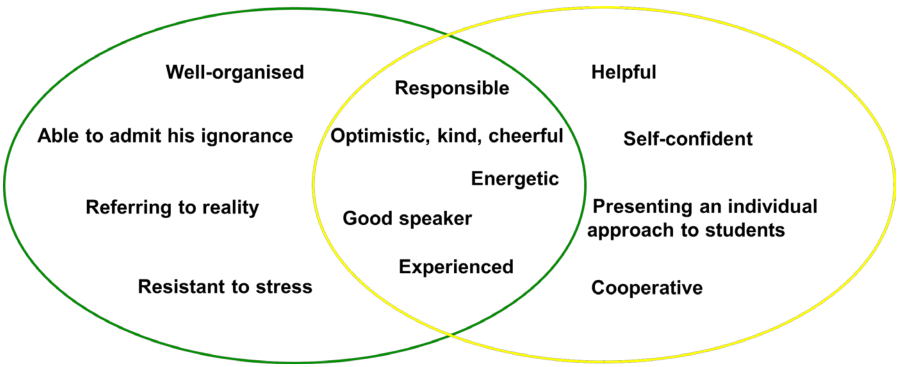


Figure. 2. Other teachers' skills (indicated by less than 10% of the respondents; green – PhD students, yellow – BSc/MSc students).

Conclusions and implications

Effective teaching cannot be described by one or two factors, it is rather a complex combination of skills belonging to the following main categories: pedagogical-content knowledge, personality traits, relationship skills and classroom management. It arises that the PhD students value the most the quality of tutoring, they need a master, who possesses a deep knowledge of the subject matter, who is honest, passionate and ensures the scientific integrity.

The BSc&MSc students expect the teacher to be 'professional and competent' – he should be able to give them a right package of knowledge and skills but they do not define precisely the components of such a package. They need a lot of attention, commitment in their problems, they value the quality of interactions between teachers and students, they welcome rules that are consistently enforced and appreciate an effective classroom coordination. The sample size in our study was small, thus the quantitative representativeness of the study is limited. Many different factors like age, gender, cultural background, educational level may influence on how the 'good teaching' is perceived. Students' perceptions about the teacher might be also different than perceptions of their teachers or parents. Bearing in mind that effective teaching should lead to the improvement of students' achievements, the further research should concentrate on the assessment of the quality of teaching against the progress being made by students.

References

Brophy J., & Good T.L. (1986). Teacher behaviour and student achievement. (In:) *Handbook of research on teaching*, Wittrock M.C. (Ed.), New York: MacMillan, p. 328-375.

Burns D., & Darling-Hammond L. (2014). *Teaching Around the World: What Can TALIS Tell Us?* Stanford Center for Opportunity Policy in Education.

Coe R., Aloisi C., Higgins S., & Elliot L. (2014). *What makes great teaching? Review of the underpinning research.* Major Centre of Evaluation and Monitoring, Durham University & The Sutton Trust.

James M., & Pollard A. (2011). TLRPs ten principles for effective pedagogy: Rationale, development, evidence, argument and impact. *Research Papers in Education* 26, no. 3, p. 275-328.

Outdoor Education

Paweł Cieśla

Pedagogical University of Cracow, Institute of Biology, Didactics of Natural Sciences Research Group, Podchorążych 2, 30-084 Kraków, pawel.ciesla.33@gmail.com,

Introduction

Holistic exploring nature by doing experiments for example in the park undoubtedly can be much more interesting than learning just some facts, theories and gaining skills in school classrooms. Learning natural sciences at primary and secondary levels of education should be realized through outdoor activities. However, effectiveness of that classes is dependent on many factors.

A lot of school excursions does not have much in common with active learning. Usually, the teacher says: we are going to the museum (or to the zoo, cinema, etc.). In the museum pupils are just watching a lot artefacts and listening a guide. If we take into account the number of information passed in a very short time, after leaving the museum a great majority of them is lost. Therefore, very often, as a result of wrongly prepared excursion, it is a lost of time which could be used in more effective way.

The real outdoor classes start with leaving the school, however, the most important things which influence on effectiveness have to be born at the preparation phase. Preparation of the good classes is the most difficult as well as the most important.

The preparation phase should contain:

– defining the goals and a topic of the excursion;

– gathering information about the place;

– pre test that checks the pupils' knowledge in this topic;

– developing activities;

– preparing equipment.

While designing such outdoor activities the interests of whole group should be taken into account. Moreover it should be adjusted to the age of the participants of the classes. At the beginning the teacher should define the aims which he would like to achieve and then plan the activities, trying to include individual interests of his pupils'. Unfortunately, very often excursions are monothematic. Pupils differ in interests - some of them prefer natural sciences, the others prefer humanistic content instead of math or science topics, so not always pupils like to take part in monothematic excursions because they find them boring.

Thus it is important to prepare the classes in a holistic way. Even if the classes have a specific theme that can be prepared in such a way as to be interesting also for people with other interests. Sometimes the place where the classes are held gives the opportunity for such approach. Depending on the topic a park, forest, zoological garden, botanical garden, museum, historical building or just a city-centre can be a good place, however the clue is to prepare a good set of activities to do. The teacher should get to know the place first before starting to design activities. The teachers need to invest time in understanding the history, culture and ecology of specific local 'places' (Tan & Atencio, 2016).

The activities ought to be prepared in such a way that could be done in reasonable time, and should shape and develop various competencies and skills of the pupils.

So far this kind of active learning has required carrying a lot of heavy and inconvenient equipment, such as atlases, books, measuring equipment. At present mobile technologies enable us to replace that equipment by one small – tablet or smartphone connected to the very huge database – the Internet. It is of crucial importance especially at the teaching the youngest children.

After the classes a teacher should check the students' knowledge and evaluate the classes. In the classroom he can do a post-test and compare the results with the pretest.

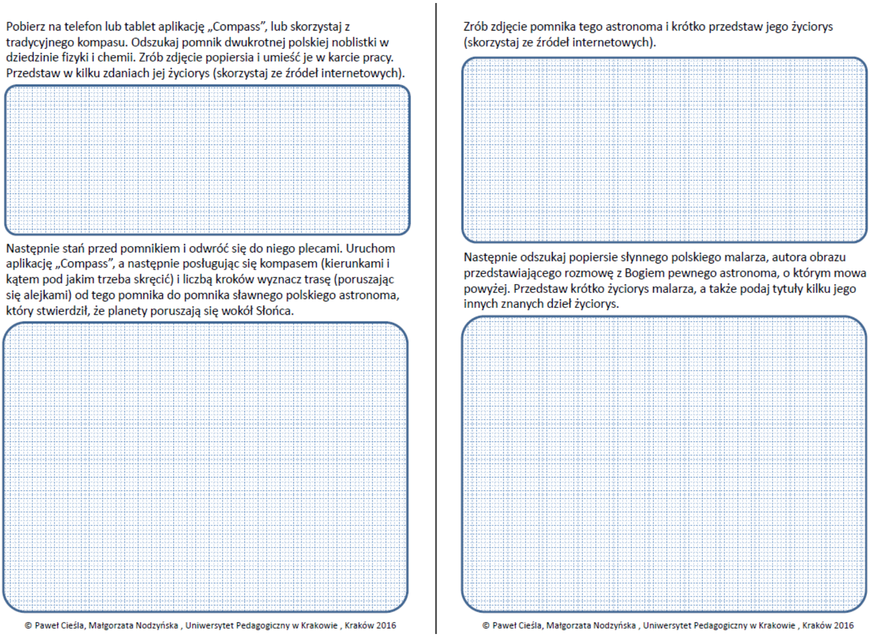
Leading the excursion in that way it becomes much more effective.

In order to teach prospective teachers how to prepare effective outdoor classes it is very important to add to the teacher training course designing outdoor activities module.

Classes in the park

For the purpose of prospective teacher's training a set of various activities that can be done with children in a park was designed. The students' workbook contained 43 various activities, which enabled holistic approach to active learning not only natural sciences but also math, history and art, basing on mobile applications and Internet resources (fig. 1.). The workbook was prepared as a PowerPoint file, however it can be exported to the application which can work online, such as Google presentations.

Each student was given a hardcopy of the workbook and his task was to go through all the activities in the park, using his mobile phone. Resolving all tasks took the students about 4 hours.



Pobierz na telefon lub tablet aplikację „Compass", lub skorzystaj z tradycyjnego kompasu. Odszukaj pomnik dwukrotnej polskiej noblistki w dziedzinie fizyki i chemii. Zrób zdjęcie popiersia i umieść je w karcie pracy. Przedstaw w kilku zdaniach jej życiorys (skorzystaj ze źródeł internetowych).

Następnie stań przed pomnikiem i odwróć się do niego plecami. Uruchom aplikację „Compass", a następnie posługując się kompasem (kierunkami i kątem pod jakim trzeba skręcić) i liczbą kroków wyznacz trasę (poruszając się alejkami) od tego pomnika do pomnika sławnego polskiego astronoma, który stwierdził, że planety poruszają się wokół Słońca.

© Paweł Cieśla, Małgorzata Nodzyńska , Uniwersytet Pedagogiczny w Krakowie , Kraków 2016

Zrób zdjęcie pomnika tego astronoma i krótko przedstaw jego życiorys (skorzystaj ze źródeł internetowych).

Następnie odszukaj popiersie słynnego polskiego malarza, autora obrazu przedstawiającego rozmowę z Bogiem pewnego astronoma, o którym mowa powyżej. Przedstaw krótko życiorys malarza, a także podaj tytuły kilku jego innych znanych dzieł życiorys.

© Paweł Cieśla, Małgorzata Nodzyńska , Uniwersytet Pedagogiczny w Krakowie , Kraków 2016

Figure 1. A page with activities from the student's' workbook.

Conclusions

The classes revealed the prospective teachers how many activities can be designed to work with children in a park and how to develop such activities. So it is hoped that some of these students will use them in the future.

References

Tan, Y. S.M. & Atencio, M. (2016). Unpacking a place-based approach - "What lies beyond?" Insights drawn from teachers' perceptions of Outdoor Education. TEACHING AND TEACHER EDUCATION Volume: 56 Pages: 25-34.

Experience and Prospects of Training for Teachers of Chemistry in Conditions of Introduction of New Educational Standards in a Classic University

Aksinya E. Yegorova

North-Eastern Federal University M.K. Ammosova, Yakutsk, Russia

Now education become the subject of many conversations. It correctly, because education is a kind of win-win investment in the future, the guarantor of sustainable development in the areas of akseologičeskih and prakseologičeskih factors group thinking.

In the educational system of Russia adopted a number of regulatory instruments, such as the Federal State standard of higher education, the professional standard of teachers and regulations governing training higher pedagogical education (2011). These documents pointed universities at redefining approaches, goals, objectives and content of teacher training-future teachers. In this regard, there have been changes in higher education curricula, there were various profiles, elective disciplines students, that is redefining the bases of the educational process. With each document and each event are thinking for a long time. This is an excuse. Education, in contrast to economics and politics, more conservatively in spirit and letter, following him can also be conceived for a long time. Basic documents of education operate within a decade at least. Therefore, create a strategy easier here than anywhere else, because education is one of the most sustainable systems of public life: education system date back to the original values and knowledge in education operate in most of their reliable, well-established structure elements (Egorova et al, 2002). This approach is also conditioned by the introduction of new European methodological categories of competence, performance units, modules, etc.

The main purpose of the regulatory documents adopted, in our opinion, it is not fixing the educational content that you want to learn, without limiting diversity and competitiveness, and set the set of mandatory requirements to graduate. New quality of education should be geared to the achievement, along with academic results, results in the acquisition of competencies, such as-"the ability to use educational opportunities Wednesday to achieve personal, metapredmetnyh and meaningful learning outcomes and ensure the quality of the educational process means the mother subject" and others. Essentially, this means that all components of the educational process in the University should be focused on achieving results, i.e. declared in FGOSe competences. In our view, such an approach most really begins to work one of the basic principles of didactics-unity of the procedural and substantive sides learning. This means that any discipline training goals, content, organizational forms, methods and tools should be brought into line with the requirements of the standard. However, in a real educational process there are two major problems that need to be addressed: a) it's methods or mechanisms for measuring results, because the result is not only a subject knowledge, but also the properties and qualities of a personality in the form of a competency. How, for example, to determine the well-formedness of socio-personal competencies as "the ability to self-organization and self-education" or "ability to work in a team, but perceive the social, cultural and personal differences" and others; b) is a teacher to the formation of polyhedral results from their students, implementing the activity approach in educational practice? Those marked with problems directly related to the issue of teacher training in the country and it is therefore necessary to refer to the question: what is the status of teacher training-teachers of biology and chemistry at the University of the Republic, as North-Eastern Federal University? Are bachelors and masters-a new generation of teachers to resolve those problems that are put in front of the school in connection with the introduction of the next-generation standard (GEF) does not regulate the content of education, and includes only the structure requirements, conditions and results of basic education programs (according to the developers of the standard, this approach ensures the freedom of choice of educational content in order to meet the educational, spiritual, cultural and subsistence needs of the individual , humane attitude towards the developing personality, her individuality and self-realisation in cultural and educational space) (The concept of a federal State educational standards for general education: project, 2008). Staging such a task put before graduate school task changes the philosophy of future staff training, which is characterized, first of all, the critical notion as "quality education", and defines competitiveness in the world market of university educational services.

North-Eastern Federal University. M.k. Ammosova, performing the social order of the Republic of Sakha (Yakutia) on teacher training, implements undergraduate four-year and five-year timing of training, such as "chemistry" with the four-year training period and "biology and Chemistry, geography and Ecology with two profiles, as well as the master- «Chemical Education» and «modern scientific education».

Practice shows that continuously reaching innovative processes in education leads to a high level of subject knowledge and teaching his technique studied ownership cannot fully characterize those requirements are reflected in the new school standards. Today, however, and the labour market significantly more "updates" their demands because the science, production does not stand still. To resolve these problems of the labour market require mobile professionals with new qualifying characteristics. Modern young man must be ready to change the trajectory of his personal development depending on the conditions of the surrounding reality. In this regard, one of the challenges of preparing future teachers-estestvennikov for a modern educational system is their inadequate preparedness to work in the context of the new GEF requirements: on the one hand, forming a multi-faceted results-competences on the basis of the activity approach, on the other-dimension mechanisms of their pupils. Thus, new demands from society to education not only at the higher teaching, but school and modern approaches to its implementation gave rise, in our view, a number of contradictions between:

– general requirements standardization of higher pedagogical education (the required level of training of bachelors and masters: well-formedness general cultural, professional, professional competences) and lack of razrabotannost′û theory and concrete realization of its methodical system in high school;

– the need to prepare in high school mobile workforce with new qualifying characteristics according to the new regulations and a lack of preparedness for the future Bachelor's and master's degrees to work in the context of the new GEF general education requirements.

Essentially we are talking about building optimal methodical system that would ensure not only the formation of the current level of competency in the GEF stated, but also create conditions for the development of personal significance for the student competencies, as methodical scholarship, horizons, thinking and experience. The basis for constructing such a methodical system of preparation of future teacher us Bachelor's and master's degrees based on public and private principles. Based on the ideas of continuity of the educational process is offered in chemistry teacher training technology professionally required (GEF) and creative levels.

The formation of necessary competencies (personal qualities of the future teacher-Bachelor's and master's degrees), characterizing the pedagogical professionalism require revising targets education, i.e. ensuring the innovative character of basic education, knowledge-based, providing balance and depth of competence-based approach, development variance of educational programs at the University. This approach assumes that modern man must not so much to accumulate knowledge and skills, how to acquire the ability to independently and together with other people to put meaningful objectives, to build a situation of self-education, search and produce tools and solutions, that is, in fact, become independent, proactive and creative (Egorova, 2014a).

Above suggests that aspects of providing training estestvennika teachers reform aimed at ensuring student autonomy and build its development trajectory, at least are three conditions:

1. Develop a flexible training plan based on the ideas of the modular-kompetentnostogo approach;

2. Implementation of the idea of modular-kompetentnostogo approach in practice;

3. The creation of an adequate system for monitoring learning achievement of planned results.

As regards the first condition-the development of flexible training plan based on the ideas of the modular-kompetentnostogo approach will generate the necessary competence (personality of the future teacher-chemist), characterizing essentially pedagogical professionalism.

The curriculum content factors won't serve the following modules:

– core modules (discipline) that define the "core" programme;

– support modules (discipline), necessary for mastering the content of the "core" programme;

– tilting modules (discipline), carrying knowledge into practice; -specialized modules (discipline) that define the orientation (profile)

Model of such a curriculum we reflected in our publications (Egorova, 2014b, 2016, Egorova & Pavlova, 2015). For realization of modular-kompetentnostogo approach in practice, it is necessary to build a methodical system to create professional needed (FGOSa) and creative levels of training teachers, which will consist of three components: 1) content-targeted, 2) processual′no_- simulation and 3) effectively-assed.

Thus, the construction of theoretical model of teacher training of bachelors and masters, as well as the realization of this model in the form of a methodical system makes it possible to create conditions for the formation of and maximizing the methodical knowledge and skills for becoming personally meaningful for the student competencies as the methodical scholarship, horizons, thinking and experience in terms of the classical University.

References

Federal State educational standards of higher vocational education. -M., (2011). p. 26

Egorova K.E., Maksimov G., Ivanov V.S., Suzdalov I.I., (2002). Sivtsev table L.a. science education is one of the guarantors of sustainable development.-researcher-Scient. CONF. "The problem of the continuing science education", 17-18 January 2002. Yakutsk: NIPK "Sahapoligrafizdat.", pp. 3-8

The concept of a federal State educational standards for general education: project. (2008). Russian Academy of education. Ed. Kondakova, Kuznetsova À.à.-m.: education.

Egorova K. (2014a). Ways and conditions for the development of the personality of the future-teacher-estestvennika in the level of education. Sbornik prispevku XXIII/ Mezinarodni conference o vyuce chemie a IX. Hradec Kralove, IX-2014. – pp.429-432;

Egorova K.E. (2014b) Factors conducive to the development of the personality in terms of integrative system of continuous classical University education/ liberal education as an imperative for the development of civil society: materials of international scientific and educational forum SVFU "Education, Forward-11.-Yakutsk: SVFU Publishing House, p. 496.

Egorova K.E., Pavlova M.S. (2015). Ways and conditions for improving the vocational and methodical preparation of teacher of chemistry in conditions of implementing GEF. In *Proceedings of the VI Interregional scientific and practical Conference with international participation*. 10-12 November 2015 g. ed. È.F. Matveeva. -Astrakhan: Publisher: Roman V. Sorokin, pp. 33-37.

Egorova K.E. (2016). Features and mechanisms of Federal State educational standards at different levels: experience and issues. In *Proceedings of the Forum with international participation "the Scientific education in the conditions of transition to the new State education standards: experience and prospects*.North-Eastern Federal University named after M. K. Ammosov. Yakutsk: SVFU Publishing House, pp. 9-15.

Science in Young People's Choices

Stefania Elbanowska-Ciemuchowska[1,2], Michał Bednarek[2]

[1]Division of Physics Education, Faculty of Physics, University of Warsaw, Poland
[2]The Main School of Fire Service; Division of Physics and Chemistry, Warsaw, Poland, stefania.elbanowska@fuw.edu.pl

Introduction

The research was carried out as an auditorium questionnaire on a sample of 543 students of first grade of upper secondary school, aged 15 years. The representative sampling was assured by taking one school from each voivodship in Poland. The aim of the survey was to determine the attitude of young Poles towards science. It was commissioned by Bayer and performed by the firm Millward Brown SMG/KRC (2011). The results were compared to those of the CKE Report (2015) on the choice of Matura subjects by the students of the last year of high school.

In the survey one looked for answers to the following questions:

- Which school subjects do upper secondary school students like?
- If they do like science subjects, what are the reasons?
- What benefits for their professional future do they relate to science?
- Do they know already what will be the direction of their future education?
- Do they want to tie their future with their favorite science subject?
- Which subjects have they chosen for the school leaving examination?

The outcome of the survey

Students rated the school subjects on a scale of 1 to 6; 6 meant the highest mark (the subject exceptionally well liked), 1- the lowest one (negative reception). The group of subjects to chose from consisted of biology, chemistry, mathematics, physics, Polish language, history, foreign language, geography and social science.

In Fig.1 the sum of indications 5 (I like) and 6 (I like very much) is shown. Based on all the students' answers (N=543)

It comes from the survey that foreign languages (42,5%) are liked most. Next on the list is Polish (32%). Mathematics takes the third place (31,5%) and is followed by biology (29,5%). History (28,2%) and social science (26,9%) go before chemistry (25,5%). Physics takes the last place on the list (18%), just after geography (21,7%).

Most of the students think that mathematics makes for an easy change of job direction and finding a well-paid occupation. The young people value more the prospective good earnings than the possibility of professional career or intellectual development.

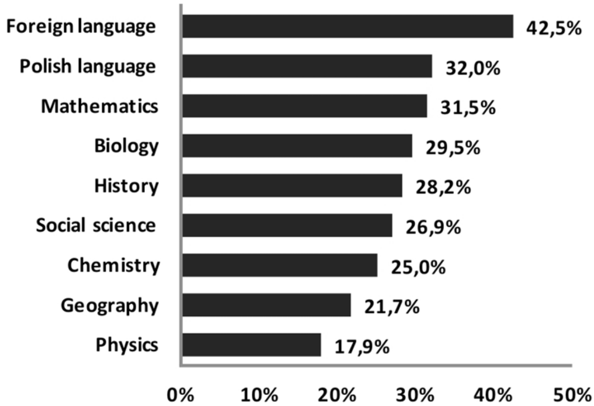


Figure 1. Which subject do students like best?

The further analysis will concern mainly position of physics and the related profits.

The students choosing physics present the following arguments. In their opinion physics allows to see various natural phenomena, describes well the world and makes it easy to understand; besides, it is interesting in itself, close to the practice, and allows to find an interesting job (Fig.2).

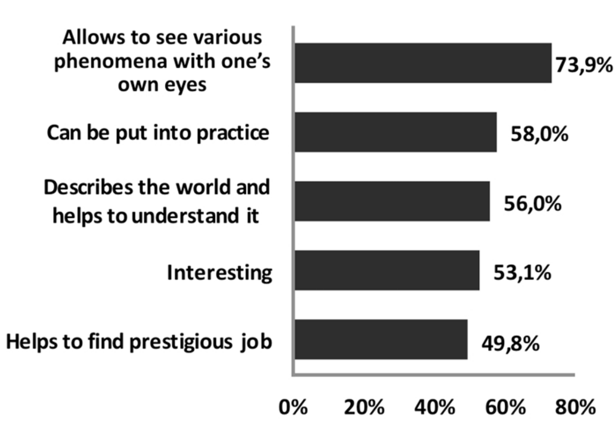


Figure 2. Why do the young people like physics?

In Fig.3 we can see the benefits related to the choice of physics as perceived by the students. According to the secondary school students the biggest benefit is the possibility of working abroad. They think it is physics among all the school subjects that gives this opportunity. Other benefits related to physics : interesting and developing job, prestigious, well-paid and career-oriented (Fig.3).

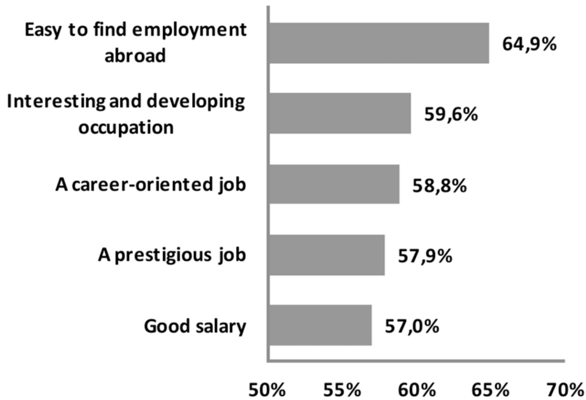


Figure 3. Professional benefits related to physics (5 characteristics with highest ratings). Based on respondents declaring liking for sciences

The agreement between the early declarations of the young people on their favorite subjects and the actual choice of Matura subjects can be checked in the CKE (Central Commission for Examinations) Report (2014).

In the school year 2015/2016 only 8,9% of students taking Matura exam chose physics. This confirms the low position of physics, even among the science subjects (Fig.4).

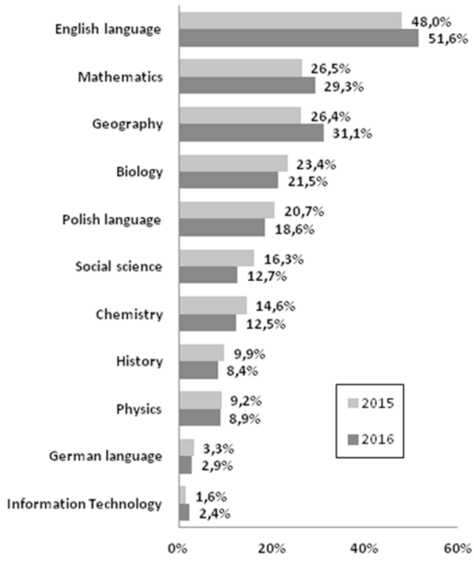


Figure 4. Ranking of subjects chosen for Matura exam in 2015/16. Based on N=275 568 (2015) and N=258 372 (2016) students taking the exam.

Conclusions from the survey

– Foreign languages are most liked subject (42,5%) of upper secondary school students.

– Mathematics is the most liked science (31,5%)

– Only 18% of students pointed physics an their favorite subject.

– Students who like mathematics pointed out, as benefit related to the subject, that it helps both to get a job and to change it.

– The choice of physics is related to the opportunity to work abroad.

Summary

Mathematics is perceived as most interesting among science subjects. This is mirrored by the choice of the extended level of Matura exam in mathematics.

The students that indicated physics as their favorite subject stressed its fascinating, experimental character.

References

Anuszewska I. (2011). Research report: Bayer barometer of education. Survey conducted by Millward Brown SMG/KRC. Results were presented during the debate at Warsaw technical University.

CKE Report (2014).

CKE Report (2015).

Personalization in Education – from the Concept to the Practice

Anna Florek

Akademia Dobrej Edukacji im. M. Płażyńskiego w Gdańsku
e-mail: anna.florek@dobraedukacja.edu.pl

The aim of this work is to describe the system of work of the school *Akademia Dobrej Edukacji in Gdańsk* - a mean for achieving the personalization of education. We summarize experiences of three years' work with students at junior high school and high school levels (ages 12-19).

Akademia Dobrej Edukacji is a school that offers innovative solutions in the areas of organization and curricula. The school concept of withdrawal from traditional lessons and grade-division was prepared and will be carried out with the support of a research personnel from universities and colleges. This concept is described in our curriculum - *Program Dobrej Edukacji* (www 1). The Academy was conceived as a laboratory in which the school of the future is being shaped. Our school is focused on the personalization of teaching. In the Academy every student has an opportunity to learn at his/her own pace. At the same time, they can maximize their progress while learning accordingly to their interests and syllabus. Creativity and individuality of the student and his/her emotional and social progress are the key factors in the Academies approach to education. Social skills improvement is the common denominator.

From the point of view of a teacher a question arises: What makes a teaching method and a strategy to be personalized? At the basic of our three years' experience some important differences in teachers' work is defined (Tab. 1).

In everyday practice of personalized education is to keep balance with all the aspects of teaching (Fig 1.). It is crucial to combine the necessary teachers' knowledge about the aims and education needs of the students with appropriate methods of how to work with the student and support him/her to enrich his motivation, awareness of goals set and the responsibility for the learning process itself.

Table 1. The characteristics of the teacher‘s work implementing a personalized education

A teacher working in the traditional education system	A teacher implementing personalized education
works with the entire class	works individually with the student, tutors individuals
plans the class curriculum	works with the student to create a plan which is related to his/her specialty (core subject) as a part of the individual educational path of development of the pupil, plans activities for a group of students who share the same (determined individually) educational goals
organizes and leads classes	organizes classes for a group of students or/and for individuals
prepares handouts for the class	prepares handouts designed for individual students regarding their special needs
assigns activities for the class	assigns tasks to individual students, they may be of different levels of complexity, regarding a variety of topics consistent with students interests, abilities and skills
chooses educational strategies for the class	applies (often simultaneously) many different educational strategies, adapted to the student
teaches cooperation for achieving the objective set for the class	teaches cooperation for achieving the objective that helps students achieve their individual goals.
sets requirements for the whole class	sets requirements for an individual student concerning his/her educational needs, interest and capabilities
performs evaluation and assessment for the class from the perspective of the whole class	performs evaluation which is carried out to verify the student's personal development plan the achievement of individual goals, spiky meet with the individual requirements, achieving significant progress with measuring and indicating the effects of work with the group

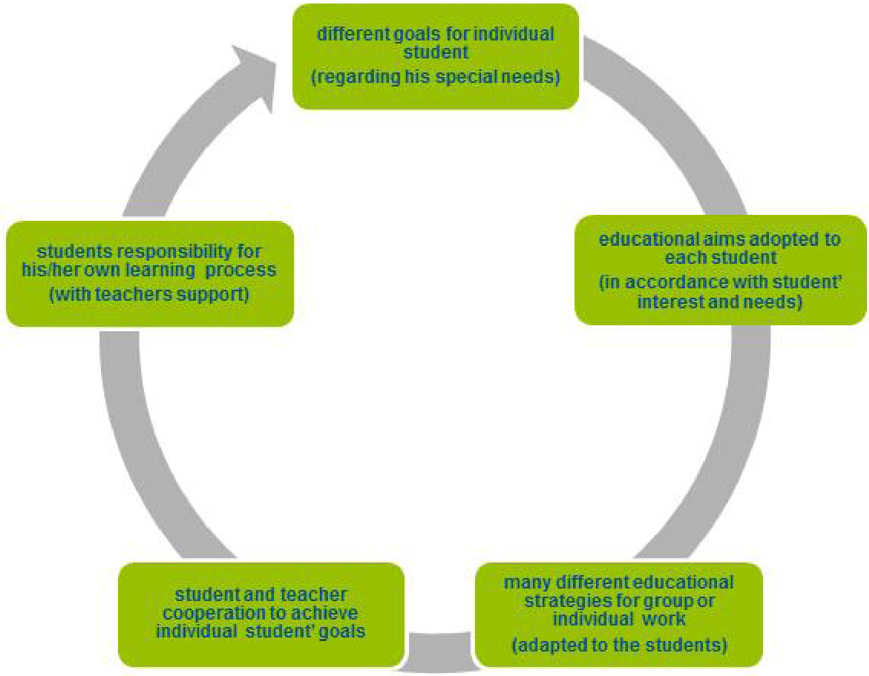


Figure 1. Personalized education

The 3 years experiences show us that the key to achieve the best educational outcome is an individual approach to capacity, capabilities, interests and passions of each student. The students become responsible for their own development and are motivated to achieve their goals.

References

www 1. Program Dobrej Edukacji, http://ide.dobraedukacja.edu.pl/p/struktura-programu-dobrej-edukacji.html.

Avogadro's Hypothesis As a Critical Moment in Inductive Approach How to Build a Concept of Particle Composition of Gases

Ľubomír Held

Trnava University in Trnava, Faculty of Education, Department of Chemistry, Slovakia, lubomir.held@truni.sk

It has been 205 years since Avogadro published his ideas about composition of gases. They were not accepted and it delayed promoting of "atomic" ideas in chemistry in 50 years. The main reason for this reluctance was probably the lack of direct evidence. There are only consequences and indirect demonstrations of Avogadro's hypothesis, mostly only visualisations or "ex post facto" speculations about consequences of accepting it.

Fundamental problem in chemistry education is creating a mental connection between macro and micro-world by our students. This problem tackles traditional topics (chemical bond, Periodic law, kinetics of chemistry reactions, movement of ions) as well as perspective topics like nanotechnologies.

We want to discuss a developing approach to introducing scientific way of thinking about composition of gases to lower secondary students in a community of experts in theory of chemistry education.

Instead of verification only "unsuccessful" attempts for falsification I

Resulting from mentioned matter of facts we are trying to find empiric demonstrations that would present a convincing proof for pupils to understand Avogadro's hypothesis as an idea connecting macroworld (volume of gas) and microworld (number of particulars).

Neither after years lasting search in the professional literature nor on the internet we haven't found suitable empiric evidence. Internet media offer a number of presentations declaring Avogadro's hypothesis explanation. In fact it is only an interpretation and terms clarification included in Avogadro's hypothesis. Eventually, it's a matter of experiments which do not contradict this hypothesis. Professional companies producing tools again based on Avogadro's hypothesis sell a complicated apparatus where you can observe volume proportions at synthesis of water from the original elements. This experiment "only" demonstrates the principles discovered by Gay-Lussac.

We have contributed quite a big effort into creating a presentation of Avogadro's hypothesis for use at schools. The result was presented in a publication (Held, 2014).

To construct a demonstration we were inspired by information that Avogadro was engaged with a study of gas expansion. We've made a following speculation. The equal volume of more gases (minimum two) was needed to take, then change the conditions (e.g. temperature) and if Avogadro's hypothesis is valid it's sufficient to show that volume of different gases has increased (decreased) the same way. The result for students will be surprising but acceptable even if not quite easily. The proof is not completely clear, it's not inductive – well accepted from the point of the positivistic methodology. We cannot simply directly calculate a number of particulars. Despite the fact that school experiment doesn't require special equipment (two bottles, e.g. of the wine bottles, with the same volume, a tank for warming up bottles, a source of heat, best quality silicon corks) it is demanding for a laboratory experience and implementation accuracy and is takes quite a long time (more than an hour).

Instead of verification only "unsuccessful" attempts for falsification II

In the next stage of our work we tried improving the experiment based on the same idea by manipulating pressure instead of temperature. To perform a demonstration experiment we need: a big plastic syringe (50 ml), approximately two-kilogram weights, a syringe cap with a piece of a hose with a clamp, gas samples (helium for children balloons is available, carbon dioxide, methane as a natural gas, butane as a gas for an igniter and certainly the air).

The procedure is as follows: Pupils (students) are given three syringes (one with salt, the second one with water, and the third one with air) in their hands and they are asked to compress the syringes. Pupils are being convinced that gases compared to substances in a different state of matter are compressible (Criswell, 2008). Then we prepare a following experiment: On a piston of an encased syringe with gas we place the two-kilogram weights. Students face the problem and are asked to make an assumption: How will the piston position change (volume of gas) at the same pressure (weights) but a different gas with a different density? The majority of students anticipate a change of volume in comparison to the first demonstration depending on the relative molecular mass of the gas particles. This assumption is in fact contradicted by the atomic-molecular theory, it originates from intuition and it is trustworthy at first sight for the majority of people. In the next step we'll demonstrate it is not true. And the volume of all available gasses at different pressure is the same (at the room temperature).

We've changed the way of thinking about verification. As mentioned earlier we will not be seeking verification but Popper's falsification (Popper, 1995). Though we eliminate a wrong and mistaken conviction to all intents and purposes "live" in front of students. A following implication results from the atomic-molecular theory: if we have two different gasses with an equal number of particles (molecules) then under the same conditions (though even changed, for instance a change of pressure) it applies that they have an equal volume. We derive (formulate) a complementary statement with students despite which could be justified by intuition is the original Avogadro's idea negation. Then we will demonstrate to the students in an empiric way that their assumption wasn't confirmed.

Subsequently we demonstrate to students the following experiment. We will gradually fill the same syringe with two different gasses and carefully load piston with weights. We find out that in all cases at the equal increase of pressure by applying a load of weights we'll gain reduced but again the same volume of gas. Though we demonstrate empirically that for the original speculation (for example that helium after compression will have smaller volume than butane) we cannot find the true evidence. Two different volumes of gases at altered (but the same for both) conditions don't have different volumes. Hence we didn't manage to discredit (to falsificate) the atomic-molecular theory (including Avogadro's hypothesis) despite our intuition that it's not possible to believe in Avogadro's hypothesis.

Conclusion

Our actual experience show that school demonstrations constructed by us are interesting and unusual, make work with gases more accessible while simple aids are used. The result is surprising, it evocates a cognitive conflict that is a good starting point for educational activities leading towards more sophisticated acquisition of terms, development of research work competencies including a contact with most abstract ideas of the science methodology.

Acknowledgements

This work was supported by Slovak Research and Development Agency under the contract No. APVV- 14-0070.

References

Criswell, B. (2008). Teaching Avogadro´s Hypothesis and Helping Students To See the World Differently. Journal of chemical education, 85(10), 1372 – 1376.

Held, Ľ. (2014). Modelovanie látky - induktívny prístup. In: Nauczanie i uczenie się przedmiotów przyrodniczych od przedszkola do studiów wyższych. Krakow: Uniwersytet Pedagogiczny w Krakowie. ISBN 987-83-7271-881-5. (pp. 117-120).

Popper, K. R. (1995). Hľadanie lepšieho sveta. Bratislava, ARCHA, (p. 229) ISBN 80-7115-113-0.

Simple Laboratory Experiments with Minerals

Alžbeta Hornáčková[1], Mária Linkešová[2]

[1]Department of Biology and [2]Department of Chemistry, Faculty of Education, Trnava University in Trnava, Slovakia
alzbeta.hornackova@truni.sk, maria.linkesova@truni.sk

Introduction

This paper is devoted to simple experiments with minerals. It is designed for teachers who want to motivate their pupils at lessons of chemistry, geology or science (Kimáková, 2008). Presented experiments need almost no chemicals and can be run in school laboratory or in the classroom. They can be used as a demonstration, motivational experiment, as well as a frontal experiment. We have chosen experiments for the detection of water in the structure of a mineral, for observation of crystallization of minerals from the solution and a proof of chemical elements in minerals (Dávidová, 1999). We use available minerals such as copper sulfate (chalcanthite), gypsum, table salt (halite) and galena. Simple chemical reactions, observation of chemical processes and changes in minerals or crystallization under laboratory conditions improve pupils' interest and specify their ideas of chemical bond and the internal structure of minerals (Turanová, Bizubová, 2002) . Experiments are sufficiently explicit, evolving fairly rapidly.

Demonstration of water in the crystal structure
experiment with gypsum

Used mineral: gypsum ($CaSO_4 \cdot 2\ H_2O$)

Natural mineral gypsum powder is heated in a test tube. It is visible that water escapes. The obtained product is hemihydrate ($CaSO_4 \cdot ½\ H_2O$). We mixed hemihydrate with water and we gained gypsum mortar. This is an old procedure, used already by the ancient Egyptians in construction.

experiment with chalcanthite

Used mineral: chalcanthite $CuSO_4 \cdot 5\ H_2O$

Chalcanthite occurs in nature in small amounts. Its crystal structure contains five water molecules. By heating above a flame water evaporates from the structure of the mineral and its color is changed from blue to white. After mixing with water, the white product will be blue again. Blue solution crystallizes in a dish and in about two days we obtain triclinic crystals.

Halite crystallization

Used mineral: halite (rock salt) NaCl

Fill 150 ml beaker with water and add 1 teaspoon of table salt. Mix it together until the salt dissolves. Put the beaker with the solution aside to a quiet place and leave the solution crystallize. After 2 weeks cubes of NaCl crystallize from the saline solution. If we want to get the crystals earlier, we may put cotton fiber into the solution.

Demonstration of metal in the crystal structure

experiment with galena

Used mineral: galena PbS

This experiment with galena demonstrates the presence of lead in a mineral. Mineral galena was broken in a mortar to small (2 mm) pieces. For the experiment we need a gas burner, charcoal, laboratory tongs and a metallic or glass pipe. We put the pieces of galena on charcoal and heat them about a luminous flame. We blow air through the pipe in flame on charcoal until the coal is red. We can observe formation of silver color bullets from the galena on charcoal. It is metallic lead Pb.

experiment with chalcanthite

Used mineral: chalcanthite $CuSO_4 \cdot 5\ H_2O$

Pour 150 ml of water into a beaker. Add 1 teaspoon chalcanthite. Stir to dissolve. Then put there an iron nail. Nail gets the color of copper. It is metallic Cu.

Conclusions

Presented experiments are reliable and were tested in many trials. If teacher follows the procedures, all experiments will be successful.

Acknowledgements

This contribution is supported by Ministry of Education of the Slovak Republic through the project KEGA 003TTU-4/2016 *Chemistry and Society.*

References

Dávidová, Š. (1991). *Základy mineralógie*. Vydavateľstvo Univerzity Komenského Bratislava, Slovakia, Bratislava.

Kimáková, K. (2008). *Úvod do štúdia didaktiky biológie*. Košice: Univerzita P. J. Šafárika v Košiciach, Slovakia, Košice (p. 152).

Turanová, L., Bizubová, M. (2002). *Didaktika geológie 3. Didaktika praktických cvičení z geológie*. Univerzita Komenského Bratislava, Slovakia, Bratislava 2002, s. 82.

Educational Means for Simultaneous Development of Chemical and Mathematical Thinking

Matúš Ivan, Renata Šulcová

Charles University in Prague, Faculty of Science, Czech Republic
ivanma@natur.cuni.cz, rena@natur.cuni.cz

The context and purpose of the framework

The advancement of society demands complexity and interdisciplinarity in approach to problem-solving. The development of education in areas of science, mathematics and technical disciplines has been reflecting these demands. Set goals point to searching for the connections among mathematics, chemistry and other sciences. These requirements can be fulfilled by creating of educational means for simultaneous development of chemical and mathematical thinking. These means include educational tasks and complex problem-solving connecting theoretical knowledge and everyday life.

Methods

Research in the area of using mathematical principles in chemistry is leading us to creation of materials and resources that will support this interdisciplinary approach to education. The effectiveness of created materials is verified in practical secondary school education.

The ideas for these materials were drawn mainly from two sources. In years 2014 – 2016 an extensive testing in chemistry was conducted among high school students as described in „The level of knowledge and skills in chemistry among secondary school students"(Cífková, 2015). Conclusions of this testing is one of these sources. The interviews with the teachers of chemistry and mathematics are the second source. These interviews are still in progress.

Results

Problematic areas and tasks with interdisciplinary elements in chemistry, mathematics and science were selected based on the results of the study. Students have got the most difficulties applying algebraic calculations in chemistry, use direct and inverse proportion, solving equations, expressing the unknown of a formula. Another area of concern is the spatial imagination, geometry and stereometry and the resulting arrangement of atoms in spatial structures and shapes of molecules (Nodzyńska, 2012). The test results have also shown that the students have many difficulties in chemical analytical tasks that require logical thinking. They interpret information from graphs and tables incorrectly

(Cídlová & Kuběnová, 2015). It is very challenging for students to plot measured values into graphs and to evaluate them statistically. Reciprocity is an important requirement for high-quality interdisciplinary tasks. The functional analysis emphasizes extensive background of chemistry for the development of theoretical mathematical skills. Students are able to plot a graph of measured values acquired during chemical experiments in the laboratory, but the challenge still remains in revealing the mathematical rule of functional dependence.

Example of a task in the area of mathematical statistics

Statistical evaluation, graph-plotting and chart-making are important skills that should be acquired by students. These skills include not only data interpretation but also creation of these statistical tools. Nuclear fission of radionuclides can be simulated through students' activity using coin-tossing (ČEZ, a. s., 1999). Students plotted their results in a graph, shown in Figure 1.

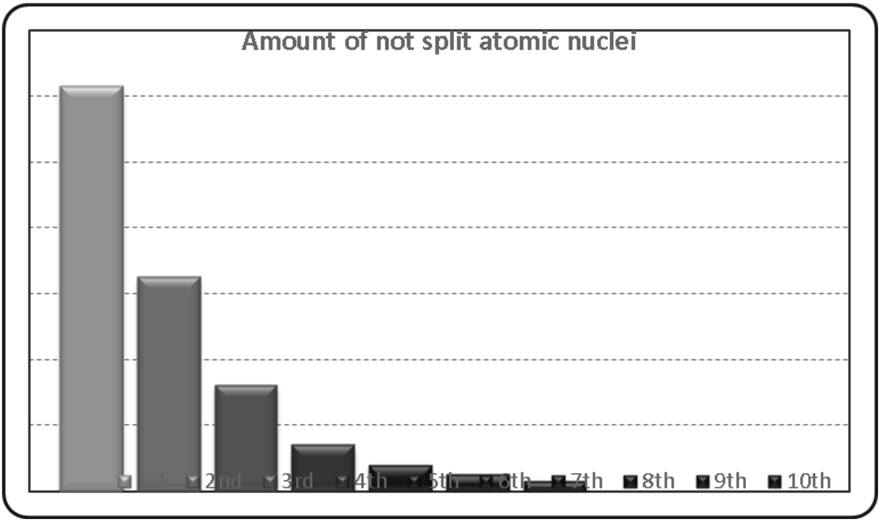


Figure 1. Experiment results of simulation of fission of radionuclides by coin-tossing

Example of a task in the area of calculations

One of examples of using calculations in chemistry is an everyday task of a chemist to determine stoichiometry of a reaction (Atkins, 2010). This task implements the principle of solving systems of linear equations. First of all it is necessary to determine the oxidation and reduction partial equations, then the first step of the Gaussian elimination method of solving systems of linear equations must be applied. It requires finding the least common multiple of amount of electrons being exchanged, as shown in Figure 2.

$$\mathrm{HCl} + \mathrm{KMnO_4} \dashrightarrow \mathrm{Cl_2} + \mathrm{KCl} + \mathrm{MnCl_2} + \mathrm{H_2O}$$

$$\text{oxidation:} \quad 2\ \mathrm{Cl^{-I}} - 2e^- \rightarrow 1\mathrm{Cl_2^0} \quad /\cdot 5$$

$$\text{reduction:} \quad 1\mathrm{Mn^{VII}} + 5e^- \rightarrow 1\mathrm{Mn^{II}} \quad /\cdot 2$$

Figure 2. Determining the stoichiometry of a red-ox reaction

Conclusions

The educational tasks highlight the usefulness of mathematics in problem-solving in chemistry. Also natural principles in chemistry present to be proof of theoretical mathematical knowledge. Practical verification of interdisciplinary tasks will be conducted with high school students the next school year. Hopefully, high school teachers of science and mathematics will be willing to use the materials during their lessons according to the results of interviews.

Acknowledgements

This work was supported by institutional resources of Ministry of Education, Youth and Sports of the Czech Republic for the support of science and research and by Charles University Research Development Schemes PROGRESS – TT.

References

Atkins P. & J. de Paula (2010). Physical Chemistry. Ninth Edition. Oxford: Oxford University Press. ISBN 978-1429218122

Cídlová, H., & Kuběnová, G. (2015). Pracujeme s grafy stejným způsobem? In: Novotná J. (ed.) 9. didaktická konference s mezinárodní účastí. Brno: Masaryk Univeristy. ISBN 978-80-210-8143-7

Cífková, T. (2015). The level of knowledge and skills in chemistry among secondary school students. Prague: Charles University in Prague, Faculty of Science

ČEZ, a. s. (1999). Half-life. Retrieved June 7, 2016, from: <https://www.cez.cz/edee/content/ file/static/encyklopedie/pokusy/pokus09.html>

Nodzyńska, M. (2012). Wizualizacja w chemii i nauczaniu chemii. Kraków: Wydawnictwo Naukowe Universytetu Pedagogicznego. ISBN 978-83-7271-751-1

Multimedia in Teaching Science

Anna Kamińska[1], Andrzej Karbowski[2], Krzysztof Służewski[2]

[1)]Institute of Physics, Pomeranian University,
Arciszewskiego 22A, 76-200 Słupsk, Poland
[2)] Didactics of Physics Division, Nicolaus Copernicus University,
87-100 Toruń, Poland, e-mail: akarb@fizyka.umk.pl

The important role of multimedia in teaching Science we have proposed already in the 90s of the twentieth century. Regular multimedia textbooks at high school level were already present on the Italian market and publishing house Dorling Kindersley published a thematic encyclopedias to teach Science subjects such as: Earth, Birds, Human Body, Animal Encyclopedia and others. At the time, we use educational software in the classroom with students and pupils come mainly from abroad. In the late 90's of the twentieth century, the first multimedia encyclopedia has been published by Polish publishers and were available on the market. The first interactive exhibition of multimedia educational software was organized by us at Pomeranian Academy in Słupsk as early as in 1997. Later, with the advent of internet, the development of new multimedia declined. Nowadays, most children and students use the Internet every day and has to deal with hyperinflation occurring here information (Karwasz, 2012). There is the problem of how to find the best information among the thousands of pages found by the search engine.

Dr. A. Kamińska has prepared a questionnaire and conducted a study in 2010 on a group of about 150 high school students. The results obtained show that they have worked with the computer an average of four hours per day (outside the classroom), of which in the Internet 3.5 hours. Again, studies were carried out in 2016 on a group of students from the same schools. It turns out that the less time students spend in front of the computer, just 1.7 hours. However, much more time they spend on the Internet - about 7 hours daily. No longer use computers, but smartphones and tablets. To study the use of multimedia, students spend only about 45 minutes. To the question: for what purpose you use your computer, we have got the following answer: games, entertainment (76 %), social media (60 %), learning (32 %), listening to (or download) music (15 %) (Fig. 1). To use the Internet met mainly positive educational function, you should try to properly direct the use of the media. Teachers should on the one hand lead properly thought-out media education, on the other hand indicate a risk of reaching there. New technologies will not be afraid, but use them as a means to achieve the desired goals.

Despite threats to modern technologies give us unlimited possibilities of science education more attractive. Speaking about the usefulness of new technologies in the educational process should be aware that they should meet certain requirements: be innovative, interactive, intuitive and have the ability to fit the individual needs of the user (Okoniewska & Meger, 2002).

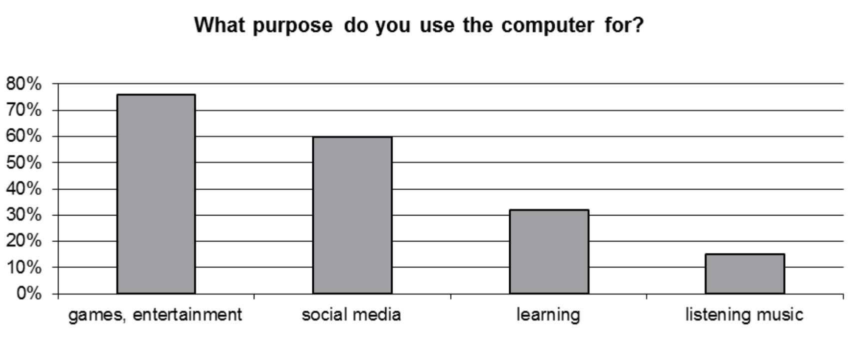


Figure 1. The results of a questionnaire conducted in the school year 2015/16 among middle school students.

Whereas the effective teaching of science with the use of multimedia resources we organized in 2015 new laboratory of Multimedia in Education and Culture at Nicolaus Copernicus University. During the classes we observed a huge interest of students in this form of acquiring knowledge. First of all, students can compare not only different contents, but also various attitudes towards presenting it – in a manner more or less effective, respecting the cognitive teaching methods. The ability to assess the suitability of available multimedia resources and their use in science education is an important competence of future teachers. The main advantage of the multimedia encyclopedia installed on computers in our new laboratory is that they are *closed resource* (CD-Roms on Science, Education and Culture), thus enabling students to concentrate on learning focused on a specific subject and activity allows to go back to try and check again.

In present paper we discuss the variety of available multimedia resources in teaching Science, respecting the division proposed some time ago (Karwasz, 2010): collection of loose files, educational pathways, encyclopedia, multimedia textbooks. collection of loose files, educational pathways, encyclopedia, multimedia textbooks. Among the multimedia, there are resources of communication with users: photos, pictures, diagrams, movies, animation, 3D animation, narratives, music, sounds. An example of a well-prepared and developed multimedia textbooks in teaching of Science is "Mobile chemistry". Of particular note is available on mobile devices (Bartoszewicz & Gulińska, 2015). To the active and creative teaching physics developed educational pathways "Physics and Toys", where playing objects become a pretext the interest in Science (Karwasz et al., 2005). The multimedia resource created at Pomeranian Academy in Słupsk in 2003-2005 had on Nicolaus Copernicus University in Toruń site more than 200000 views in six years, and exercised a strong influence on development of interactive Physics in Poland (Fig. 2).

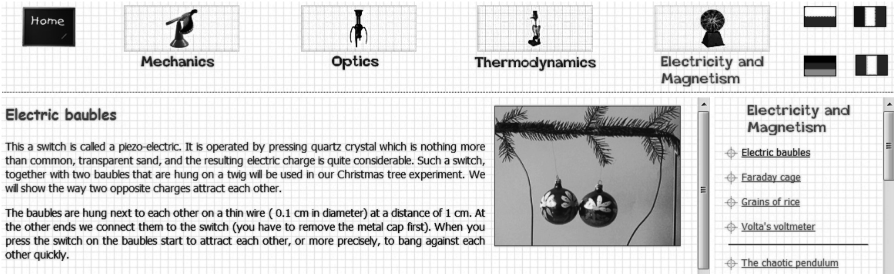


Figure 2. "Physics and Toys" educational pathways. On the screen you can find photos, videos, a brief description of the experiment and the 1.5 bit of new information to the user.

In order to effectively, interdisciplinary and modern science teaching we prepared a website "Physics for Everyone" (http://dydaktyka.fizyka.umk.pl) in the Didactics of Physics Division at Nicolaus Copernicus University in Toruń. On our website you can find, for example: video recordings of lectures and lessons, short movies with experiments, animations and simulations of phenomena, interesting photos and diagrams, descriptions of experiments, press review, twitter, educational materials for pupils, students and teachers. Every day we observe from 500 to 1000 hits different users. In summary, we find that the multimedia in teaching Science allow students to: make more attractive learning process, consolidate the knowledge, focus students on knowledge transfer, illustrate the phenomenon hard to imagine and impossible to carry out, increase the effectiveness of teaching Science, stimulate the activity of cognitive and creative.

References

Bartoszewicz M., Gulińska H., (2015). *Rola mobilnych technologii w nauczaniu chemii,* w Edukacja a Nowe Technologie w kulturze, informacji, komunikacji, Wydawnictwo Naukowe UMK, Toruń.

Karwasz, G. (2012). *Hyper-constructivism as an answer on the hyper-inflation of information* (in Polish), in: Media Education in the Post-modern World, ed. B. Siemieniecki, Sci. Editors UMK Toruń, (p. 365-386), http://dydaktyka.fizyka.umk.pl/Pliki/Media_2012_GK.pdf

Karwasz, G., Wróblewski, T., Kamińska, A. & Rajch, E., (2005). *Toys and Physics*, CD-Rom, Soliton Musics and Education, Sopot, 2005, http://dydaktyka.fizyka.umk.pl/zabawki1

Karwasz, G. (2010). *Are media needed in didactics?* (in Polish) in: Media in Education, Culture and Social Change – Cognitive Aspects, ed. S. Juszczyk, Adam Marszałek Editions, Toruń, 167-172, ISBN 978-83-7611-566-5. http://dydaktyka.fizyka.umk.pl/Pliki/Czy_media_w_dydaktyce_sa_potrzebne.pdf

Okoniewska A. & Meger Z., Środki multimedialne w nauczaniu fizyki, *Multimedia tools in teaching Physics,* (in Polish), Fizyka w Szkole, 1/2002, pp. 30- 36.

Teacher's Influence Compared to Students' Attitude Towards Learning Chemistry in Gimnasium Age Group

Agnieszka Kamińska-Ostęp

Faculty of Chemistry, Department of Chemical Education, Lublin, Poland
aostep@poczta.umcs.lublin.pl

Stimulating students' interest in chemistry is a key issue for teacher's success. This success manifests itself in students' achievements as far as, acquisition of chemical knowledge is concerned as well as in the fact that students find chemistry as a subject interesting and learn it willingly. Teaching abilities consist mainly in creation of such conditions during the lesson that students' interest in the subject is stimulated.

One of teacher's basic features to be a requisite of proper influence on the educational process is student's acceptance. This feature is connected with apprehension of students' needs and aspirations by the teacher as well as with working out skills of mutual listening and understanding each other in the student-teacher contacts. This can be also achieved by empathy. This skill enables teachers to understand students better and adjust their behavior to their needs. The other features being communicative and genuine by the teacher allow to diminish distrust barrier of students towards teachers, promote learning, create better atmosphere during lessons and build confidence in the teacher. Understanding between the teacher and student enhances interest in the subject and willingness to learn it (Zimbardo,1999).

Each class possesses more or less talented students with better or worse achievements. The latter can have some difficulties with learning, understanding the material taught using a given method and didactic aids while brighter students acquire better results. Therefore it is advisable for the teacher to apply individual approach creating the atmosphere respecting others, selecting additional adequate didactic materials which will assist the cognitive process of the students having difficulties with simultaneous increase of their learning motivation (Kamińska-Ostęp, 2011)

The teachers obtaining the best effects express the expectations in a clear way and are consistent in their action. Problem methods, chemical experiments and association of theory with the phenomena observed every day affect significantly inclination to learn (Burewicz & Gulińska,2002). Discussion during the lessons is another way to make students think critically, apply the acquired knowledge to solve problems and make decisions or do other activities requiring intense intellectual efforts. Using chemical experiments, showing relations between theoretical knowledge and what can be observed in everyday life intensify students' inner motivation which is of significant importance during learning. Another important skill of the teacher is apprehension and praise of student even for a minor success. Thus the student realizes that the teacher wants him to acquire knowledge and continues education. However, this is connected with another skill and willingness to devote extra time for extra curriculum activities. Activities of compensation character or that developing student's knowledge are very favorable contributing to better efficiency of both the teacher and student. Such behavior brings closer students to teachers and make students be confident of success.

Checking and estimation of teaching results is an important part of the whole educational process and is associated with the teacher. Their aim is not only comparing the results obtained by the student with the assumed educational aims but it indicates how effective teacher's work is (Walberg, Paik, 2000).

The main aim of the studies was to determine the factors influencing effective learning of chemistry by junior secondary school students. Of special importance was to study the factors affecting students' motivation for learning chemistry which is connected with the teacher –its characteristics and skills.

The studies included 384 students of whom 229 were from municipal schools and 155 from rural schools. The questionnaire including the questions among others, about the teacher's personality was applied. The obtained replies will provide the information how the teacher can arouse students' interest in chemistry and what attitudes and skills the "ideal teacher" should possess.

Given the enormous influence of the teacher on students' learning process, they were asked to indicate the actions the teacher should change to increase their will to learn chemistry. The municipal school students mentioned "performing a larger number of chemical experiments", and "applying more didactic aids e.g. models, foils, films" during the lesson which would facilitate understanding of the subject as the most essential activities encouraging them to learn chemistry. On the other hand, the rural school pupils stated that "organizing excursions and various thematic visits" as well as "performing a larger number of chemical experiments" would encourage them to learn chemistry. For both groups of students' encouragement to take part in chemical competitions does not affect willingness to learn chemistry. Another question required pupils to point out to characteristics and skills of the ideal teacher. As follows from the analysis of the questionnaire for the students of the former municipal schools the most important was to be like by the teacher 85%. Another essential feature was to be friendly 80%. The reserved 17% and firm as well as demanding 13% teacher will not be appreciated by those students. For the students attending schools out of the cities the most important is for the teacher to be friendly 76% and another feature to like students 61%. According to them being flexible 15% and firm as well as demanding 13% are the least important features. As for the teacher's skills the municipal junior secondary school students regard to be the most important good explanation of chemical contents 89% and performing a large number of experiments 76%. The rural school students expressed the same opinion. Proper explanation of chemical contents was chosen by 80% whereas performing a large number of experiments by 74%. 3% of municipal school students do not approve of the teacher who would explain chemical contents well but would be unfriendly for then.

For the out-of-town school students carrying out a lot of tests is the least appreciated teacher's activity. The some number 5% of rural school students do not believe that oral testing of knowledge during each lesson is helpful. 8% of students do not appreciate highly the teachers who explain chemical contents well but are unfriendly.

As follows from the questionnaire pupils want to be motivated to learn 72% of municipal school students and 63% of rural school students and stimulated to activity 49% of municipal school students and 48% of rural school students. 26% of municipal students and as many as 50% from the rural areas like to be praised even for small successes. Thus the praise is a good motivation for further learning.

The results of studies showed that the teacher affects significantly students' approach to the subject and will to learn. This includes both his character and skills. Being friendly and just for the students is the most important for them. The studies show favorable effects of motivation and praise even for small achievements on students' attitude to learning.

References:

Burewicz, A., & Gulińska, H. (2002). „Dydaktyka chemii", Wydawnictwo Naukowe UAM, Poznań, 2002

Kamińska-Ostęp, A., (2011). Indywidualizacja w nauczaniu chemii – wyzwaniem dla nauczycieli? Monografia pod red. M. Nodzyńskiej Metody motywacyjne w nauczaniu przedmiotów przyrodniczych. UP Kraków

Walberg, H.J., & Paik, S.J. (2000). "Effective educational practices" Educational Practices 3

Zimbardo, P.G. (1999). Psychologia i życie, Warszawa, Wydawnictwo Naukowe PWN

How Colours Are Created?

Grzegorz Karwasz, Andrzej Karbowski, Krzysztof Służewski

Didactics of Physics, Aleksander Jabłoński Institute of Physics,
University Nicolaus Copernicus, 87100 Toruń, Poland

Purpose

The previous (valid from last three years only) scholastic reform in Poland introduced "Science" as the main subject for the humanistic profile in lyceum. A grid of twenty five subjects, in a vague idea of the proposing experts of an interdisciplinary character, have been established by the Ministry. Subjects in the vertical contain physics, chemistry, biology and geography and in the horizontal grid define problems, like energy, water as a substance, human emotions etc. In the very private opinion of those experts the choice of subjects was rather causal. Moreover, no university in Poland prepared teachers according this reform and the Ministry allowed *any* teacher to deliver lessons in Science. This is highly harmful, as the majority of the adult society will lack the scholastic cv in detailed sciences. In the opinion of an educational expert from England (Chris Stuchbury, 2012) this an "upside-down system".

The goal of the present action was to define some interdisciplinary didactical paths, understand different aspects of them, publish their descriptions in didactical articles and posters, and finally implement them in a series of lessons for children of different (8-18) age.

Methodology

Perception of colours, starting from their physical principles, through the emission and absorption lines coming from the chemistry, to the biology of colour receptors in different biological species can be example of an interdisciplinary path through Science. The way of preparing such a project took several years. In the first implementation, within EU "Science & Society" 20772 programme entitled "Physics is Fun" we started from physics of colours: RGB basic scheme in the emission and CMYK scheme in the absorption. In a didactical poster we showed where different combinations of colours can be found in the surrounding us objects (Krzysztofowicz, A., Kruczek, Ł, Karwasz, G). The title of that work was "Pink glasses", as funny sun glasses for children were analyzed as optical filters.

More recently, we made a systematic separation between the physical principles (Karwasz, 2012) of colours appearing (refraction like in a rainbow, diffraction like on a CD or on the photonic crystals of the blue *Morpho* butterfly (L. P. Biró *et al. 2003)* and the chemistry (i.e. configurations of electrons in atoms and molecules). The chemistry enters into colours starting from the emission spectra of helium vs. nitrogen (both of them seem pink in the discharge tubes), to follow with the explanation of the observed hydrogen spectrum (atomic, but partially non-dissociated H_2) and a neon discharge (again pink, but containing also green emission lines). Physics and chemistry must be combined in order to explain colours in crystals, say precious stones, like Cr^{3+} ions in Al_2O_3 matrix, i.e. ruby crystal, Fe^{2+} in SiO_2, i.e. amethyst, Fe^{+2} in Al_2O_3, i.e. sapphire.

The biology enters in scene when we speak about IR detectors at viper heads, on UV perceptions by bees, on complex colour vision by some butterflies (Morell, V. 2016).

Results

A real challenge is not to talk about colours but to organize such a path into an entertaining interactive lecture. Analysis of colours requires spectrometers. In the case of discharge tubes simple diffraction glasses are sufficient. But already for children sun glasses an absorption spectrum must be recorded on a professional spectrometer. How can it be overcome in an interactive show?

Adding and subtraction of colours can be done with three, separate RGB LED lights. We start from an attempt to guess colours of artificial hair that wear two models chosen (in a complete darkness) from the public, see fig. 1a. As the colours of the hair are on purpose chosen not to be RGB (they are pink, yellow, orange, light green) the public, to their great astonishment (and also to the astonishment of the models) fails in guessing any of these colours. In order to explain didactically the basic colours we use an overhead projector and a set of didactical filters (Educational Innovations) and ready snapshots from objects around us (Krzysztofowicz, A., Kruczek, Ł, Karwasz, G).

Surprisingly, also in apparently simple physical objects like a rainbow (i.e after rain not in a glass prism) or soap bubbles complex colour patterns appear: due to the diffraction (rainbow) and to the destructive interference (soap bubbles and other thin films, like petrol on water). This is easy to show, but first the attention of the public must be triggered, asking a relative question: “what colour is the pink lamp?”

Entering more deeply into absorption spectra, today a highly amusing part of the lecture is identifying different organic components (coumarine, chlorophyll, quinine) inside commercially available beverages. A stimulated emission of different vodkas and grappas are particularly astonishing, see “equipment” in fig. 1b. We use a set of three portable LED lasers (red, green, violet). Combination of these lasers allows almost to determine the taste of beverages, without trying them.

The public reacts with interest, and their attention during a 60 minutes lesson is kept without problems, see fig. 1c. The didactical output, as obtained from discussion with single persons after the lecture is quite various: a director of the institute was surprised by the interactive play with models, a professional scientists (in Physics) was astonished by the presence of IR detectors on the head of a viper, a student liked the analysis of vodka with lasers.

Fig.1. Snapshots from interactive lectures on colours: a) astonishment of the public (and two models) that nobody guessed colours of the artificial hair under selective RGB illumination by LEDs; b) the discussion (with an university teacher) on the emission and absorption spectra requires a number of chemical species (cleaning agents from kitchen, alcoholic and non-alcoholic beverages, flowers etc.); c) a real challenge is to keep

attention of the public (at different ages) fir the whole 60 minutes lesson; d) teachers ask detailed explanations on preparation of the experiments (photo Maria Karwasz).

Perspectives

The main target group of our interactive lecture are teachers. In fact, as seen from their reactions, see fig. 1d, they are quite interested. Our aim is to furnish teachers with the ability to perform some simple experiments (tonic water with blue laser, spectrum analysis of fluorescent lamps using a CD as a diffraction grating, colours of soap bubbles, UV and temperature sensitive papers [6] etc.). From the requirements for this simple equipment we know that the message is perceived.

The perspective would be to license such lessons into professional institution dealing with the science divulgation. A second goal (unfortunately little realistic) would be to convince the decision-makers on the educational system in Poland that any reform can bring interesting outcome, provided a necessary time for preparing scientifically sound, didactically simple and publicly interesting interactive discovery paths (in any subject, not only Natural Sciences) is left.

References

Chris Stuchbury, Open University Milton Keynes, *private statement*, Toruń, 2012.

Educational Innovations. Science Classroom Learning Tools, www.teachersource.com

Krzysztofowicz, A., Kruczek, Ł, Karwasz, G. *Pink glasses*, EU S&S 02702 Poster, http://dydaktyka.fizyka.umk.pl/Physics_is_fun/posters/gir-pink.ppt

Karwasz, G. *Rubies, gold glass and Brazilian butterflies, or on colours in physics, chemistry and biology,* Chemistry in School (in Polish) 3/2012, 5-13.

L. P. Biró *et al. (2003) Role of photonic-crystal-type structures in the thermal regulation of a Lycaenid butterfly sister species pair*, Phys. Rev. E 67 (2003) 021907

Morell, V. (2016). *This butterfly has extreme color vision*, Science Magazine, Feb. 2016

Problem-Solving Scheme a Key Step in Conceptual Physics Learning

Lorena Kelo[1], Marie Dede[2], Esmeralda Guliqani[3], Sotiraq Marko[4]

Albania, lorena.kelo@yahoo.com

The science of physics neither raises nor solves the "problems" of teaching the laws of nature discovered so far. Ways of conveying knowledge of physics are considered by the methodology of teaching physics. Teaching Methods in physics is a science of its own, with precise laws and rules. The focus of many studies on physics education is based precisely on problem solving, as one of the main ways of conceptual learning. The ways of solving are based on known and experimented scientific strategies. The article deals in theory with solving strategy of physics problems, including the development, execution and control, and ranks the results of practical application of the solving scheme, as well as reveals the obvious difference between the students who were taught using this strategy versus those who were taught using the traditional way of problem solving. In the end of this cycle we noticed improved skills in interpreting the physics phenomena of the problems in the group of students where we applied the problem solving scheme. Their conceptual formation was also improved. This result takes us closer to the final goal, preparing future teachers who are more complete in the teaching methods.

Methods

Solving a physics problem usually breaks down into three stages:

1. *Design a strategy* . (Apalkov, V. (2007)).
2. *Execute that strategy* (Heller, P. & Hollabaugh, M. (1992)).
3. *Check the resulting answer* (Styer, (2002)).

Results

Quite a few researchers complain about the fact that students solve problems mechanically (Bolton, J. (1997)). For this reason some authors argue that the most effective way of acquiring physics is the independent solving way of not very complicated problems. Different researches in physics teaching have offered specific useful strategies on problem solving.

Thinking about problem solving strategy mentioned above we used the scheme below for solving problems with one group of students and compared their results with a group where never used the scheme (The results taken are shown in Figure 1 and Figure 2).

The scheme is:

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

Solving the problem

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

Second phase: Mathematical aspect (Perform mathematical actions, which lead to a solution with symbols, Verification of results with the evidence of units (an indispensable condition))

Comment of theoretical result (Discussions for a new and deep physical interpretation, Discussions of special matters)

Comment of quantitative results after the numeric replacement of variables (Solution with symbols is a substitute for Numeric data, Discussion of numeric value)

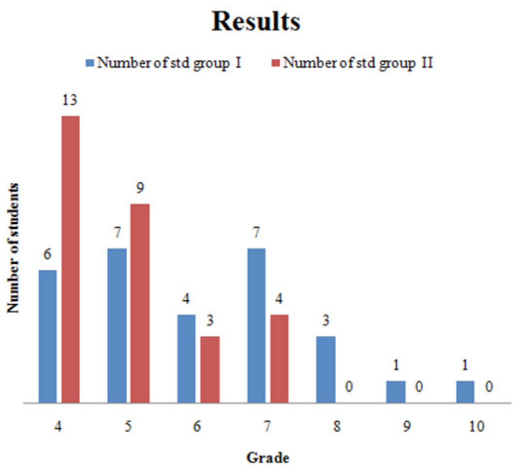


Figure 1. Results for two groups of students where we used and didn't used the problem-solving scheme. Branch: Mathematics-Informatics

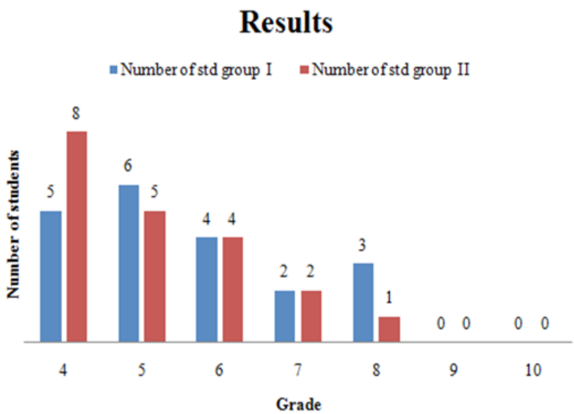


Figure 2. Results for two groups of students where we used and didn't used the problem-solving scheme. Branch: Information-Technology

Conclusions

- Solving problems in Physics is easier if we use a scheme to solve them.
- Students have the opportunity to organize their knowledge in physics
- The results of groups where we applied a strategy are significantly higher.
- A considerable part of the students were able to explain the physics phenomena conceptually.
- We should widely apply the problem solving scheme not only in Bachelor level, but also in other level of education, in order to create students who can assimilate the physics concepts in a more logical way, instead of a mechanical way

References

Apalkov, V. (2007). *How to draw a picture. Physics problems*, Department of Physics and Astronomy, Georgia State University, Atlanta Georgia, Vol.1. Retrieved from solvephysics.com

Bolton, J. (1997). *Developing students, physics problem-solving skills*. Journal of Physics Educations (32) p.176-185

Heller, P. & Hollabaugh, M. (1992). *Teaching problem solving through cooperative grouping. Part 2: Designing Problems and structuring groups*. American Journal of Physics, 60 (7), p. 637-644

Styer, D. (2002). *Solving Problems in Physics*. Oberlin College Physics Department. Retrieved from oberlin.edu/physics/dstyer/SolvingProblems.html

The Phenomenal Analysis of Problem Solving Success Within the Distance Course for Physics Olympiad Solvers

Marián Kireš, Ján Kušnír

Division of Didactics of Physics, Institute of Physics Faculty of Science, P.J. Šafárik University in Košice, Slovakia
e-mail: marian.kires@upjs.sk, jany.kusnir@gmail.com

Motivation

As a member of European Talent Support network, our faculty staff carry out series of different activities targeted to gifted students. Special attention should be dedicated to students in first year of upper secondary level school, because right after starting new school level they are looking for new challenges. Gifted or motivated students creates group with small numbers of participants within one classroom and therefore they are usually without special teacher´s assistance. Besides, many of teachers haven't own experiences with Physics Olympiad tasks solving and aren't skilled to help them. In order to solve such situation we are using of internet and learning management system (Chao, 2009) for non-formal education related to systematic support of Physics Olympiad solvers.

Distance course

Our course was professionally created by experienced teachers and researchers in Didactics of Physics, eight years before. It was evaluated during three years trialing as output from PhD thesis.

Systematic approach to solving of problems with argumentation is implemented. Distance course offers possibilities easy to share materials and to administrate quite a big group of participants from different places outside our city. From our perspective it's also a tool for teacher training, because they also can participated with their students. How it works. Each year 15 topics related to actual Physics Olympiad tasks are selected (The Committee of Japan Physics Olympiad, 2014). Three levels of solved and unsolved tasks are prepared as exemplary problems. All links to related learning materials, methodological instruction for teachers, exemplary solutions with comments and 11 home assignments are prepared. Running of the course starts with course promotion, students´ recruitment and users´ identification. Our last group consists of 80 registered participants from 13 schools.

The phenomenal analysis of home assignments

For evaluation of students´ success we pre-selected following phenomena:

writing of physical quantities from task, situation sketch, problem identification, mathematical description and general solution, exact calculation, formulation of answer, mathematical tools, using of physical quantities, and using of Pythagorean Theorem. Within home assignments (T1 – T 11) pre-selected phenomena (P1 – P9) are occurred as is shown in Tab.1.

Table 1. Pre-selected phenomena and their occurrence in home assignments.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11
P1	0	1	1	1(3x)	1	1	1	1	1	1	1
P2	0	1	1	0	1	1	1	1	1	1	1
P3	1	1	1(3x)	0	1(4x)	1(3x)	1(3x)	1(3x)	1(3x)	1(2x)	1(3x)
P4	1(3x)	0	1(2x)	0	1(2x)	1(3x)	1(2x)	1(3x)	1(3x)	1(3x)	1(2x)
P5	1(4x)	1(3x)	1(2x)	1(3x)	1	0	1	1	1	1	0
P6	1	1	1	1(3x)	1	1	1	1	1	1	1
P7	0	1	0	0	0	1	0	0	0	0	1
P8	0	0	0	1	0	0	0	0	0	0	0
P9	0	1	0	0	0	0	1	0	0	1	0

After all 11 home assignments in total 387 comments and ratings to each student were processed. Number of solved home assignments during the course are described in Fig. 1.

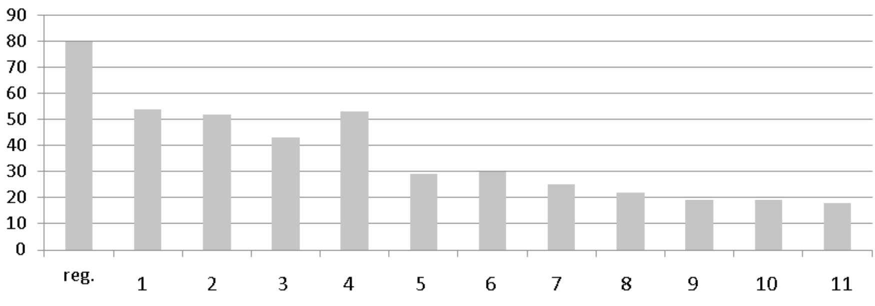


Figure 1. Number of solved home assignments.

As the best solver´s success we can consider success greater than 75% and submission of all home assignments. Within our group it concern to 13 participants. There are no special phenomena influenced reduction of rating. The second monitor group (12 participants) are solvers which not solved all tasks, but finished the whole course. Finally we have third group of solvers (38 participants) which finished task solving before the course end. The problematic phenomenon and number of participants finished because of these failure are observed in tasks 1, 2, 4 and 5 (Tab. 2).

Table 2. Problematic phenomenon influencing finishing of course.

Task	Problematic phenomenon	No of finished participants
1	P4: mathematical description and general solution	7
2	P1: writing of physical quantities from task, P6: formulation of answer	3
4	P4: mathematical description and general solution, P6: formulation of answer	15
5	P4: mathematical description and general solution, P6: formulation of answer	5
6, 7	P3: problem identification P4: mathematical description and general solution, P6: formulation of answer	6

Conclusions

The new topic focused on mathematical description, general solution and formulation of answer, must be added into the course content. After the middle of the course the group of participants must be separated into two subgroups with different level of next tasks and their grades. Also stronger involvement of teachers after the 1st half of school year is needed.

Acknowledgements

This work is the result of the Erasmus+ project 2014-1-DE01-KA203-000694, SciVis and Slovak research and development agency grant VEMIV (Research on the efficiency of innovative teaching methods in mathematics, physics and informatics education) APVV-0715-12.

References

Chao, L. (2009). Utilizing Open Source Tools for Online Teaching and Learning, IGI Global, UK, 2009, ISBN 978-1-60566-376-0

The Committee of Japan Physics Olympiad, (2014). *Physics Olympiad - Basic To Advanced Exercises*, ISBN: 981455667X

Amusing Chemistry

Ewelina Kobylańska

University of Hradec Kralove, Faculty of science, Czech Republic
kobylanska.ewelina@gmail.com

The inspiration for the work was inventing a creative way to engage the youth in chemistry. Nowadays there is a belief that life sciences, particularly chemistry and physics, are less and less interesting due to them being difficult (Elbanowska, 2010).

Didactics searches for more and more modern didactic methods and solutions to present in the easiest possible way the issues that cause trouble to students in the given field (Paśko, 2012).

This possibility opened up by running chemistry club in the junior high school, where I teach chemistry. The equipment in the chemistry classroom in our school is poor. Experiments conducted in class involved mainly food products and items from students' surroundings. It was a big advantage because students started not only to combine knowledge with practice but also use it in their daily lives, in the kitchen, at home, or while reading product labels (Nodzyńska, 2009).

Indicating the relationship between theoretical knowledge and reality as well as natural phenomena with which students deal daily has led to an increase in their interest in the subject and motivation to learn (Cieśla & Nodzyńska, 2007).

During initial classes, the students got familiar with the chemistry lab (reagents, laboratory glassware, reading the symbols of harmful compounds – pictograms). Then, during subsequent classes, they conducted experiments within colorimetry, that is determination of chemical compounds using different kinds of indicators (phenolphthalein, methyl orange, universal indicator paper, litmus, red cabbage juice, tea essence). They also learned about the significance of the pH of solutions in our daily lives. During the next cycle of classes, the students created models of different atoms, delving into their construction. Then, the students from the chemistry club went to the Malopolska Night of Scientists 2015, where they took part in workshops and chemical demonstrations, discussing topics of transparent soap, polyurethanes and egg shell and leaf extract fluorescence. Subsequent classes were devoted to the water composition, its viscosity, surface tension, the study of its physical states and the properties of the supercooled liquid. During next classes, the students carried out an experiment which aimed to show the density of different substances. Then, the students focused on the corrosion phenomenon, environments in which corrosion occurs faster, and ways to protect items against corrosion. One of the topics covered during the classes was also "iodine clock reaction", namely getting to know and taking advantage of the properties of vitamin C. Next classes were devoted to the educational project related to chemical demonstrations. The students selected experiments which they later practiced with the teacher. The project involved two trips to the Pedagogical University of Cracow to participate in the workshops and chemical demonstrations. The outcome of this work was preparation of the students' performance, presented at school on the Day of Talent Discoverers 2016. As part of the said workshops, the students learned to make and purify silver (Tollens' test), and carry out effective chemical demonstrations using fire. The most important element was the youth's practice within experimental design and adding appropriate proportions to obtain the best results of the show. The students also broadened their knowledge about the properties of metals, salts, hydroxides and acids. It was fantastic for them to present the results of their work to children from the University of Children and Parents in Cracow, and they have very positive memories of both youth and children before whom they performed.

At each class, photos were taken and videos were filmed using smartphones. Based on these materials, movies which present what the students did at each class were made. Films were put on the social network account opened by the students. In the final class, the students made their film about the difference between the phenomenon and the chemical reaction for the purpose of the ADAMED competition.

Links to examples movies:

https://www.youtube.com/watch?v=bFEDzhJxlNU
https://www.youtube.com/watch?v=iuvrR-rcHnc
https://www.youtube.com/watch?v=LN30JBYqh5o

References

Cieśla P., Nodzyńska M. (2007). Kitchen or laboratory-chemistry for gourmets. In *Technical Creativity In School's Curricula With The Form Of Project Learning* (pp.173–177). Portorož, Slovenia.

Elbanowska-Ciemuchowska, S. (2010). *Zainteresowania młodzieży naukami ścisłymi*. Warszawa, Poland: WUW.

Nodzyńska M. (2009). Między zabawą a chemią. In M. Bilek (Ed.) V*yzkum, teorie a praxe v didaktice chemie*. Hradec Kralove, Czech Republic: Gaudeamus.

Paśko, J. R. (2012). Metoda czy konieczność innowacji w nauczaniu chemii. In J.R. Paśko (Ed.) *Innowacja treści i metod nauczania w przedmiotach przyrodniczych* (pp. 7–17).; Kraków, Poland: Uniwersytet Pedagogiczny w Krakowie.

The Choice's Preference of Mathematical Tasks of Secondary School's Students

Petra Konečná, Věra Ferdiánová

Konečná Petra, CZ, Ferdiánová Věra, CZ,
Petra.Konecna@osu.cz, Vera.Ferdianova@osu.cz

The context and purpose of the framework

From 1995 to 2007 results of Czech students in mathematics deteriorated most of all the countries that took part in the international research of Mathematics and Science Education TIMSS. Although the results of Czech students within the research of TIMSS 2011 and PIRLS 2011 were above the average, they achieved the worst results in mathematics (Tomášek et al., 2012; Kramplová et al., 2012). One of the main reasons for the lack of success of many students in mathematics is that the student's knowledge is formalistic. Pupils minimize their focus on the required knowledge only; they reproduce the subject – matter without understanding. They are not able to apply the gained knowledge, strictly distinguish the school information from situations in the real world (Mikulčák et al., 1968). Results of our research focused on monitoring the choice and success rate when solving mathematical and chemical problems of varying difficulty from a simple reproduction up to solving problematic tasks by students at secondary schools showed that students are able, in most cases, to answer simple question aiming at reproduction. They avoid solving of unusual problems and problems requiring complex mental operations, application and creative thinking (Konečná & Solárová, 2015).

One of the reason why we encounter these problems is no or low motivation of pupils to be interested in math. Very often mathematics is useless topic without connection with real world, boring subject and very difficult. We try to change this negative view of pupils and to show that mathematics can be useful, real, interesting and entertaining. One of an activity aimed at this objective is thematic day with a mathematical competition for secondary school students which we organized at our faculty.

Description of the competition

We organised a thematic morning for students of different types of high schools in the Moravian-Silesian region. 150 students in total aged 16 – 18 took part in this event. We have prepared 40 mathematical problems concerning eight topics, always with five problems in each of them: modification of algebraic expressions, axial and central symmetry, numbers and operations, word problems leading to simple equations, logical word problems, adding a magic square, solving Futoshiki puzzles and folding a tangram according to a template.

Students formed five-member teams and they were supposed to solve the problems in 20 minutes in total; nevertheless, it was impossible to finish all problems within the time limit provided because of the time demand. Problems were mixed up and students could choose at their discretion. No matter how difficult the problem was, each team was given one point for each correctly solved problem. If they solved it incorrectly or did not solve it at all, they were given no points and were not penalized at all. The objective was to receive as many points as possible within a team, i.e. to solve as many problems as possible within the given time.

With regard to the said goal of students (to get as many points as possible) we expected that students would prefer and would succeed particularly in problems where they know procedures for solving and in problems that they would find easy; then on the basis of one quick successful solution, they could have been selecting next problems of a similar type. In fact it was different. That decided us to examine results of the competition closely.

Data Analysis and Results

Problems in the first four topics are usual problems and can be found on a regular basis in mathematics education of the upper stage of basic education and at high schools. Remaining topics aim at unusual problems. We focused on problems that traditionally do not occur in classes; students do not practice the solution procedure in advance and yet the problem is tempting for them. In addition to the division of problems into usual and unusual ones, with regard to partial sections of mathematics and to types of the needed intelligence we divided problems into geometry problems (symmetries and tangrams), word problems (standard word problems and logic problems) and algebraic problems (other problems). We were interested, what is the preference when selecting the problems. Do the students prefer school problems which they are familiar with and should the solution processes be adopted and automated by students? Are students more successful with solving standard school problems? Are problem selection and success influenced by the mathematical field?

The evaluation was managed by descriptive statistics and the analysis of variance (ANOVA) within which we tested whether there are statistically significant differences between the results of the monitored values with individual topics, groups and categories into which the problems were classified. First we carried out the analysis of problem selection preference. Students preferred unusual problems more. They showed the greatest interest in tangrams and magic squares. In terms of tangrams each team made use of all five problems offered; with magic squares it was the same with the exception of one team. There was also great interest in the topic of symmetries and futoshiki. On the contrary, the word problems experienced the lowest interest. In the second stage we analysed the relation between the number of successfully solved problems and all that. We noticed the lowest number of the solved problems within the word problems; only 4 problems were solved out of the 150 problems in total. On the contrary the highest figure concerning number of the solved problems was noticed within the magic squares. The ANOVA results confirmed statistically significant differences between the selected types of problems and between the group of usual and unusual problems. And it was the same even in case of mutual differences between all categories of problems – geometric, algebraic and word problems – which were confirmed as well. While monitoring the number of the solved, or let us say completed, problems the statistically significant differences were again confirmed within all monitored categories. Nevertheless, the trends that were observed here were not as clear and unequivocal as they were with the number of the preferred problems. Rate of successfully solved unusual problems exceeded the rate of the successfully solved standard school problems only in the category of word problems and algebraic problems. However, with the geometric problems you could notice the opposite trend. It even dropped below the algebraic problem category value. One of the reasons can be the proved declining level of spatial imagination ability (Molnár & Tláskal, 2012), which – in combination with less known and less practiced type of a problem – decreases the success in problem solving despite its high attractiveness.

Conclusion

Our results has shown that geometric problems have a high motivational potential although solving them is not easy for students. On the contrary, word problems have the lowest success rate as well as the lowest incentives. Results also showed that students found unusual problems more interesting. Although they are not used for them that much and they do not practise those solving processes, their average success rate with these nonstandard problems turns out to be higher than with standard problems.

References

Konečná, P. & Solárová, M. (2015). Secondary school student' knowledge level in the field of application problems in mathematics and chemistry. In *Proceedings of the international conference APLIMAT 2015* (478 – 489). Bratislava: STU Bratislava.

Kramplová, I. et al. (2012). *Národní zpráva PIRLS 2011.* Praha: Česká školní inspekce.

Mikulčák, J., Hradecký, F., Zedek, M. & Malina, Š. (1968) *Metodika vyučování matematice na školách II. cyklu – I. část všeobecná*. Praha: SPN.

Molnár, J. & Tláskal, J. (2012). Prostorová představivost nejen v matematice. *Linguistica* [online]. 22 November, 67-74 [cit. 26. 8. 2014].

Tomášek, V. et al. (2012). *Národní zpráva TIMSS* 2011. Praha: Česká školní inspekce.

The Use of "Entertainment-Education" in Teaching Chemistry, Taking into Account Pupils with Special Educational Needs

Wioleta Kopek-Putała, Martin Bilek

University of Hradec Králové, Faculty of Science, Department of Chemistry, Hradec Králové, The Czech Republic, kopek.putal@gmail.com, martin.bilek@uhk.cz

Introduction

"Entertainment-Education" (also called "Edutainment") is generally recognized as a "process of purposely designing and implementing media messages to both entertain and educate, in order to increase audience members' knowledge about an educational issue" (Singhal & Rogers, 2004). Entertainment-education is a form of knowledge transfer with the entertainment element often used in pre-school and early childhood education in order to stimulate child development, among others. It is evidenced by many Polish and foreign teaching portals such as:

- learning site Ciufcia (www.ciufcia.pl),
- educational platform for children Squla (www.squla.pl),
- educational site Poisson Rouge (www.poissonrouge.com),
- TV channel Mini Mini (www.miniminiplus.pl),
- educational TV program for children Sesame Street,
- children's university (http://uniwersytetdzieci.pl/uniwersytet),
- educational games, for example, learning apps (https://learningapps.org/),
- Kahoot platform (https://kahoot.it/#/),
- PhET Interactive Simulations (https://phet.colorado.edu/),
- educational museums and centers,
- scientists days and nights, school and university open days, educational workshops,
- science festivals (Nodzyńska, 2009),
- educational games based on experiments (Hellberg, Bílek & Rychtera, 1999).

Methods

Edutainment is popular among younger school groups; therefore, studies have been conducted on whether the idea of transfer of educational content in the form of entertainment has educational values among students of an older age group.

What was also studied was the preferences relating to the particular tools in the comprehensive learning of this type of selected topics in chemistry in junior high school. The study, being a case study, posed the question: How to attractively and effectively teach chemistry to a student with learning difficulties? The study included a junior high school student who has been under the care of Psychological and Pedagogical Counseling Center (hereinafter PPP) since the early years of primary school. The student has been diagnosed multiple times and has opinions of PPP indicating generalized learning difficulties, difficulty concentrating, impaired processes of memory, attention and association and weakening of the effectiveness of memory learning. During the study, different tools in learning chemistry were used on the example of two key chemistry teaching-learning issues: chemical reaction equation and chemical laboratory. The tools used were classified into two groups. The first includes teaching-learning without the support of Information and Communication Technologies (hereinafter ICT) and the second method is based on the use of games and activities using ICT. In the groups, different ways of learning were contrasted, and the optimal method of discussion and assimilation of the issue for the studied student were sought, taking into account the achieved: performance, attitudes, emotions and preferences of the student. Games used involving ICT are: equations and a swing, equations and sandwiches, interactive virtual lab.

Results

This article discusses a fragment of study results concerning the student's preferences. Based on Table 1, we can see that learning through fun is the way preferred by the student subjected to this study. These classes were rated 6 or 5 on a scale of school grades (equations and a swing - 6, equations and sandwiches - 5, interactive virtual lab - 6).

Table 1. Results of the student‘s preferences.

The topic carried out in the class THE Equations of Chemical Reactions	Evaluation	The topic carried out in the class Chemical laboratory	Evaluation
Working with a descriptive text	2	Educational film (TIK)	5
Equations and a swing (TIK)	6	Work with verbal instruction discussed by the teacher	2
Equations and sandwiches (TIK)	5	Virtual interactive laboratory (TIK)	6
Static drawing	4	Work with text – illustration for laboratory work	1
Model animation (TIK)	5	Experiment conducted by a student	6
Work with teacher's verbal instruction	3	Demonstration	6
Programmed learning (TIK)	6		

Conclusions

Actions whose main objective is education in the form of entertainment based on ICT are more preferred by the student compared to other ways of learning. It can be concluded that the choice of methods and forms of teaching-learning has a positive impact on learning outcomes (discussed in Kopek-Putała, 2015) and can be used in the course of normal school activities. By applying the principles of effective learning using games and ICT, we can make learning more attractive to the current student commnity, including students with learning difficulties. We should bear in mind that the purpose of edutainment is not to replace the classical school education, but only to support it.

It can be confirmed by the increasing number of schools which enrich their educational workshop in the various types of games that are programmed specifically for teaching a particular subject. The game can check the student‘s knowledge without assessing them by school grades. Additionally, it enables them to play it again. Thus there is a shift away from boring and monotonous forms of lecture in favour of more engaging and motivating systems of education and entertainment.

Educational games based on ICT are certainly a good tool which, when used properly, can increase the attractiveness and effectiveness of learning (Kopek-Putała & Nodzyńska, 2015 p. 100)**.** Skillful use of games stimulates interest in the lesson topic as well as positively impacts the improvement of the students' attitude to the subject (Hellberg et al., 1999; Gulińska, 2008).

Acknowledgments

The article is supported by Specific Research Project of the Faculty of Science, University of Hradec Kralove, Czech Republic Nr. 2119/2016

Literature

Gulińska, H. (2008). Gry edukacyjne w nauczaniu chemii. In A. Surdyk & J. Z. Szeja (Eds.) *Homo communicativus*, 2(4)/2008 *Kulturotwórcza funkcja gier.* Poznań: UAM.

Hellberg, J., Bílek, M., & Rychtera, J. (1999). Hra jako didaktický prostředek zpřístupňování přírodovědného učiva. In Š. Ligas (Ed.) *Hra - prostriedok formovania osobnosti - Zborník príspevkov z vedeckej konferencie s medzinárodnou účasťou*. Banská Bystrica: UMB, 1999, (pp. 11 - 20). ISBN80-8055-266-5

Kopek-Putała, W. (2015). Traditional teaching methods versus ICT-enhanced teaching at educating a dysfunctional student, on the example of the issue of balancing equations of chemical reactions. In H. Cídlová (Ed.) *XXIV. Mezinárodní konference o výuce chemie Didaktika chemie a její kontexty - Sborník příspěvků z konference.* Brno: PdF MU, (pp. 80-87) ISBN 978-80-210-7996-0

Kopek-Putała, W., & Nodzyńska, M. (2015). The Implementation of the Educational Project "Feel the Chemistry" in Junior High School with Students with Learning Difficulties. In M. Rusek (Ed.) *Project-Based Education in Science Education XIII.* Prague: PdF UK, (pp. 95-100), ISBN:978-80-7290-864-6

Nodzyńska, M. (2009). Między zabawą a chemią. In M. Bílek (Ed.) *Výzkum, teorie a praxe v didaktice chemie : sborník přednášek 19. Mezinárodní konference o výuce chemie*, *2. Část: Přehledové studie a krátké informace.* Hradec Králové : Gaudeamus, (pp. 126-131).

Singhal, A, & Rogers, E. (2004). The status of entertainment education worldwide. In A. Singhal, M. Cody, E. Rogers, & M. Sabido (Eds.) *Entertainment-education and social change*: History, research, and practice. Mehwah, NJ: Lawrence Erlbaum.

Teaching the Greenhouse Effect in the Slovak Primary Schools from the Teachers' Perspective

Lucia Kováčová

Faculty of Education, Trnava University, Trnava, Slovakia
lucia.kovacova@tvu.sk

The context and purpose of the framework

Greenhouse effect and the related topic of global warming are currently highly topical issues that are subjects of much debate including international political level. As A. Bozdoğan (2009) states, it is an even more important step to inform the society about the global warming on all levels of education.

Many researches, however, point to the fact that pupils, teacher candidates and even teachers themselves do not have correct ideas about these issues (e.g. Dove, 1996; Groves, Pugh, 1999; Bozdogan, 2009, Çeliker, Kara, 2011; Dawson, 2012). Based on the foregoing facts we consider it necessary to find out to which extent the topic of the greenhouse effect is taught in the Slovak primary education system, how the primary school teachers approaches this topic and how do the teachers of primary schools in Slovakia understand this phenomenon.

Aims, objectives and overview of research methods

The primary objective of our research was to analyze the current state of teaching greenhouse effect within the Slovak elementary schools from the teachers' perspective. Our secondary objective was to uncover understanding of teachers themselves about this phenomenon. To achieve this goal we have used the method of individual semi-structured interview, which helped us to maintain the topic of the conversation but at the same time it allowed participants to apply their own perspective and experience (Hendl, 2005).

We have conducted eight individual interviews with the second primary education stage teachers from Slovakia. All the participants were experienced teachers with an average experience of 12 years. All the interviews were recorded on a dictaphone and the average duration of an interview was 18 minutes. In total we have recorded 142 minutes of spoken text and processed it into a verbatim transcript.

In the first part of our research we have analyzed this verbatim transcript and realized the process of open coding. We have created categories and subcategories through this process. The most important of them will be presented in the following section.

Results

Teaching of greenhouse effect concept

In the introductory part of the teaching of greenhouse effect teachers usually use methods such as interview, discussion and mind map. From the content side, teachers point mainly to the pollution and negative influence of human activity on the environment and they do not describe greenhouse effect as a natural process, which is essential for the life on the Earth.

For better understanding of this phenomenon by pupils, teachers often refer to it using the example of the gardener's greenhouse. According to some interviews, teachers also use personification, which helps pupils to imagine how our Earth can 'feel' when we pollute our environment. Using pictures and schemes about greenhouse effect is also a very common tool for teaching. The main sources of these pictures are school books, internet, but a lot of participants also draw this process on the board. We have to say that teachers often describe these pictures and processes of greenhouse effect in a desultory and incorrect way.

The general model of teaching this topic is to briefly inform pupils about greenhouse effect and about other environmental problems by teachers and then (maybe the next lesson) it is taught by pupils. They can prepare a presentation, poster or project on a selected topic. According to our results it is important for teachers that pupils can practice their presentation and communication skills.

Pupils' ideas about the greenhouse effect from the viewpoint of teachers

During the interviews we have also asked the teachers how the pupils perceive the theme of greenhouse effect and what their concepts about this phenomenon are. We were interested whether teachers see some misconceptions among the pupils. The interviews show that according to the teachers the greenhouse effect is not a problematic theme for the pupils. Several of the teachers told that pupils understand this topic and they like it.

Teachers thus do not see the problem in the complexity of the topic, but rather in the inadvertent attitude of the pupils and their reluctance to learn, or in their inability to repeat what they have learned. However, some of the teachers also pointed to the fact that pupils often show confusion between the themes of greenhouse effect and other environmental problems.

Teachers' ideas about the greenhouse effect

By analyzing the interviews we have tried to find out what the teachers' ideas about the greenhouse effect are. During the interviews we have identified uncertainty when they were asked to describe greenhouse effect. Some of the teachers were also using expressions that were inaccurate. As an example we can mention confusion between the terms weather and climate, which was also described by V. Dawson and K. Carson (2014).

Confusion between the problems of greenhouse effect and ozone layer depletion is very common not only among pupils and teacher candidates but we have identified it also among some of the teachers. In one of the interviews a teacher showed us a poster prepared by her pupil for the lesson focused on the greenhouse effect. When we asked the teacher why her pupil painted there an ozone layer and different types of emissions of the greenhouse gases, she was unable to determine whether the image represents the topic of greenhouse effect or ozone layer depletion.

Conclusions and implications

Despite the fact that teachers do not consider the topic of greenhouse effect being difficult and problematic for the pupils, our results showed that teachers themselves were often uncertain and inaccurate in their descriptions of the teaching of this topic.

Conclusions arising from our research survey indicates that it is important to stress the significance of the environmental problematic because it is a highly topical problem concerning the whole society. It is therefore necessary to correct the widespread misconceptions not only among the pupils but first of all among the teachers themselves.

Acknowledgement

This work was supported by the Slovak Research and Development Agency (SRDA), contract no. APVV-14-0070.

References

Bozdoğan, A. E. (2009). An investigation on turkish prospective primary schol teachers' perceptions about global warming. *World Applied Science Journal*, 7(1), (p. 43-48).

Çeliker, D. & Kara, F. (2011). Determining the misconceptions of pre-service chemistry and biology teachers about the greenhouse effect. *Procedia Social and Behavioral Sciences*, 15, pp. (2463-2470).

Dawson, V. & Carson, K. (2014). *Climate change & The greenhouse effect.* Australia: University of Western Australia.

Dove, J. (1996). Student teacher understanding of the greenhouse effect, ozone layer depletion and acid rain. *Environmental Education Research*, 2(1), (pp. 89-100).

Groves, H. F. & Pugh, F. A. (1999). Elementary pre-service teacher perceptions of the greenhouse effect. *Journal of Science Education and Technology*, 8(1), (pp. 75-81).

Hendl, J. (2005). *Kvalitatívni výzkum. Základní metódy a aplikace.* Praha: Portál.

Motivation of Medical Students for Better Understanding of Fundamental Sciences Applications in Medicine

Eva Kralova

Institute of Medical Physics, Biophysics, Informatics and Telemedicine, Faculty of Medicine, Comenius University, Bratislava, Slovakia;
e–mail: eva.kralova@fmed.uniba.sk

The context and purpose of the framework

The contribution describes main ideas of the scientific project „Motivating factors of medical students for better understanding the fundamental sciences knowledge in relation to medical diagnostic and therapeutic methods", which was financially supported by Ministry of Education, Science, Research and Sport of the Slovak republic.

Key challenge of the project is to find incentive approaches, strategies and resources in teaching process and change negative attitudes of medical students to the sciences in a positive way.

Methods

To realize the purpose of the project it is necessary to develop a joint effort of teachers providing sciences teaching at medical faculties and especially to create an opportunity for their communication with teachers of preclinical and clinical teaching subjects. Only by such model of cooperation could be specified necessary core of knowledge of the sciences needed for further study at medical faculties, but also for medical practice.

Selection of the appropriate (i.e. efficient, effective) teaching strategy is based on the proper selection and arrangement of the content, in the correct formulation of the objectives, the proper selection and use suitable teaching aids, among which we include in particular the methods, forms, educational technique and technology.

Results

Our research team has prepared and analysed the anonymous questionnaire for students and teachers of fundamental sciences (medical biology, medical physics and biophysics, medical chemistry and physiology) directed on current attitudes of students and teachers how to learn and teach sciences at medical faculties. In the first step we analysed respondent´s answers about students motivation to study medicine at our faculty (Faculty of Medicine Comenius University – FM CU). (Fig. 1)

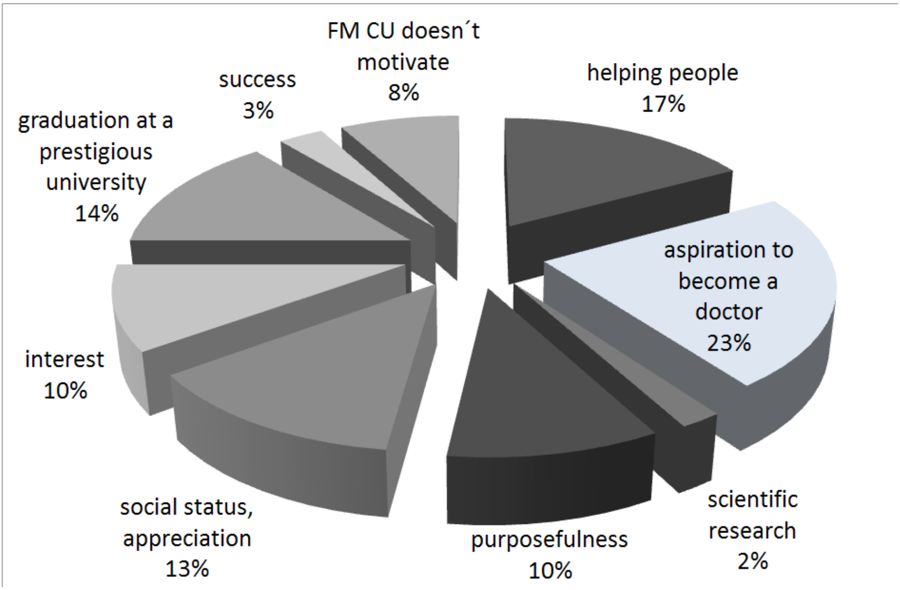


Figure 1 Students motivation to study medicine at FM CU in Bratislava

Conclusions and implications

Medical study and practice place high demands on analytic and synthetic thinking of students and health professionals. These requirements could be developed during university study of fundamental sciences.

Our project has the ambition to create a functional model of feedback algorithm to optimize the teaching and learning of sciences in medical faculties, which could improve educational level and international competitiveness of graduates.

The fulfilment of this goal requires wider communication of university teachers of sciences with both clinicians and medical students and also further training of university teachers in higher education pedagogy.

Acknowledgements

Contribution was supported by GP KEGA Ministry of Education, Science, Research and Sport of the Slovak Republic № 003UK–4/2016.

References

Bernadičová, H., Benedeková, M., Babál, P., Bernadič, M. (2007). Prieskum názorov absolventov Lekárskej fakulty UK v Bratislave (Surveys of graduates of the Faculty of Medicine in Bratislava). Revue ošetrovateľstva, sociálnej práce a laboratórnych metodík, XIII/2007, č. 1, p. 24-26.

Kralova, E., Kukurova, E. (2008). Use the questionnaire to receive feedback information on the teaching. Research in Didactics of the Sciences (Eds. M. Nodzynska, J. R. Pasko), Krakow : Uniwersytet pedagogiczny im. Komisji Edukacji Narodowej, 2008. p. 219-222.

Slavík, M. et al. (2012). Vysokoškolská pedagogika. Pro odborné vzdělávání (Higher education pedagogy. For vocational training). Praha : Grada Publishing a.s., 256 s., 1. vydanie, 2012. ISBN 978-80-247-4054-6.

Svetlíková, L., Kráľová, E. (2011). Motivačné prístupy, stratégie a prostriedky vo výučbe fyziky (Motivational approaches, strategies and resources in teaching physics). Ústav biofyziky LFUK v Plzni : Abstrakty XXXIV. Dnů lékařské biofyziky, s. 49, Plzeň, ČR.

Vašutová, J. (2002). Strategie výuky ve vysokoškolském vzdělávání (The strategy of teaching in higher education). Praha : UK PedF, 282 s., 2002. ISBN 80-7290-100-1.

Elements of the IBSE Methodology in the Irresistible Project – the Experience of Polish Teachers Participating in the Project

Małgorzata Krzeczkowska, Iwona Maciejowska, Ewa Odrowąż

Department of Chemical education, Faculty of Chemistry,
Jagiellonian University in Kraków
malgorzata.krzeczkowska@uj.edu.pl

Wishing to bring the concept of Responsible Research and Innovation closer to the society and seeking to promote IBSE, the European Commission has proposed a grant competition as part of the actions coordinating and supporting the FP7-SCIENCE-IN-SOCIETY-2013-1 Programme, Activity 5.2.2 Young people and science, Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education. In the competition, the subsidy was granted among others to the project with the acronym IRRESISTIBLE (*Including Responsible Research an innovation in cutting Edge Science and Inquiry-based Science education to improve Teacher's Ability of Bridging Learning Environments*), coordinated by the University of Groningen (The Netherlands) with the Polish partner – the Jagiellonian University in Kraków (Faculty of Chemistry and the University Museum – Collegium Maius) [www.1.].

IRRESISTIBLE aims at designing and implementing the actions that will support the involvement of students and society in the process of Responsible Research and Innovation, including in particular the preparation of students' interactive exhibitions on the latest scientific achievements, challenges and dilemmas associated with the process of research and its implementation. The Irresistible project suggests, just like other European projects such as ESTABLISH, SAILS, or Fibonacci, using for that purpose the Inquiry-Based Education as the strategy for effective shaping of attitudes and developing students' inquiry skills. An effectiveness of IBE methodology through increasing motivation, interest and understanding is main research activity of many scientists (Finlayson, Maciejowska & Čtrnáctová, 2015).

The indicator concerning the use of IBSE that was common to all partners turned out to be the 5E instructional model based on the constructivist approach to learning, where each of the 5 E's describes a phase of learning: Engage, Explore, Explain, Elaborate, and Evaluate (Bybee et al, 2006), extended while working in the IRRESISTIBLE project with 2 additional E's: Exchange and Empowerment.

In each of the ten project countries a Community of Learners (CoL) were formed to develop a thematic module for schools. These groups comprised of school teachers, education experts from universities, exhibition experts from museums / science centers and researchers from the thematic field. The educational material developed was used by the CoLs teachers with their students. After phase I of the project (CoL1) we have ten modules on various RRI-topics that have been tested in five to ten classes each. In phase II, the teachers from the first phase are each training five colleagues (CoL2). [www.1]

In order to prepare the Col2 teachers for the project activities, in the school year 2015/2016, at the Faculty of Chemistry of the Jagiellonian University in September 2015, a few-day-long autumn school was organized – a series of lectures, workshops, tours and laboratory classes. The Col2 teachers represented various types of schools (lower secondary schools, general and vocational upper secondary schools), they came from various places in southern and central Poland, and they demonstrated very different experience in IBSE (or even the lack of such experience). It was the reason, among other things, why the autumn school curriculum included: an introductory lecture on IBSE, group exercises allowing to diagnose the existing teachers' misconceptions and attempting to work out a common, more unified image of the strategy entitled "IBSE – do we all understand it in the same way?", and laboratory classes enabling the participants to experience the inquiry themselves, which was especially valuable for those teachers who had never had an opportunity to experience it before.

In the further activities of the Col2, the teachers' task was to prepare an outline/scenario of a science lesson, implemented in the teachers' own schools based on the IBSE methodology. The scenarios were then discussed at the meetings of small Col2 groups, and the teachers were asked to complete a written questionnaire concerning the outlines prepared by them. The questionnaire address those issues: How did the teachers cope with the task? What turned out to be easy? And what was difficult? Which elements required further clarification? In the talk, a preliminary analysis of the questionnaires will be presented. The analysis showed that teachers have a problem with formulating research questions, verifiable hypotheses referring to the question and the determination of variables. Poland is not the only European country in which, on the one hand, the so-called scientific method similar to IBSE is present in theory of education since the mid-twentieth century, and on the other hand – very few teachers understand and apply it on an everyday basis. Therefore, it seems that the conclusions drawn on the basis of the analysis of the above mentioned 27 teachers may be also applied in other countries with similar history and educational tradition.

References

Bybee, R.W., Taylor, J.A., Gardner, A., Van Scotter, P., Carlson Powell, J., Westbrook, A. & Landes, N. (2006). The BSCS 5E Instructional Model: Origins, effectiveness and applications. Retrieved from http://www.bscs.org/bscs-5e-instructional-model

Finlayson, O. E., Maciejowska, I. & Čtrnáctová, H. (2015). Inquiry Based Chemistry Instruction. In: I. Maciejowska & B. Byers (Eds.), A Guidebook of Good Practice for Pre-Service Training of Chemistry Teachers (107-124). Krakow, Poland: Faculty of Chemistry Jagiellonian University

[www.1] IRRESISTIBLE project homepage http://www.irresistible-project.eu, accessed: January 25, 2016

Teaching Secondary School Students How to Derive Information from the Reference Literature Chemistry Materials

Małgorzata Krzeczkowska and Barbara Krajewska

Jagiellonian University, Faculty of Chemistry, Kraków, Poland
malgorzata.krzeczkowska@uj.edu.pl

Background, framework and purpose

Herein we discuss how to teach secondary school students how to derive information from reference literature chemistry materials. A proposal where the periodic table of elements, the activity series of metals and the solubility table are used was developed. The context of our proposal refers to the topic connected with reading date in a graphic form (Nodzyńska, 2008).

The proposal had the objective to formulate a teaching technique that could help students realize the amount of information provided by the above tables. This included questions, such as those regarding:

the periodic table of elements:

What information can be derived from the number of valence electrons? What information can be derived from how the electronegativity of elements changes? What information can be derived from how the atomic radius changes? Where is the border between metals and nonmetals? Can patterns of chemical activity be derived from the location of metals and nonmetals in the table? Can patterns of (i) basicity of oxides and hydrides, (ii) strength of bases, (iii) acidity of oxides, and (iv) strength of acids, be derived from the location of metals and nonmetals in the table?

the activity series of metals:

Which metals react with acids under room temperature to produce hydrogen? Which metals react with hydrochloric, nitric(V) and sulphuric(VI) acid? Which metals are active metals? Which metal oxides are basic? What do we know about the reactivity of metals in reaction with aqueous salt solution?

the solubility table:

Which nonmetallic oxides are acidic in nature? What are the typical oxidation numbers of metals in their compounds?

Methods

The proposal was practiced with 76 students (95% girls, 5% boys; 82% 17 years old, 18% 18 years old) of 6th Upper Secondary School in Kraków as well as with this year 14 students of the post-graduate teachers training at our Faculty. As an example, we present the note at the end of classes devoted to the usage of periodic table of elements (Fig. 1).

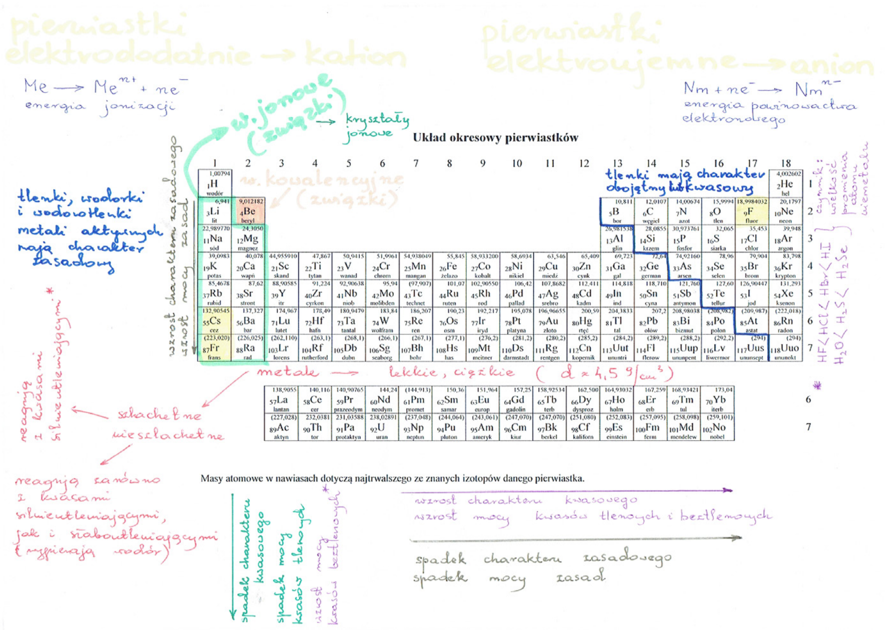


Figure 1. The student, note.

The school students and teachers were surveyed in order to collect their opinions on this kind of school activities. Questionnaires included questions, such as: a) for school students: Do teachers at school teach how to use the reference literature chemistry materials? Do students participate in activities based on this problem? b) for teachers: Do you run this kind of activities with school students? Do you teach how to use the materials? What are the benefits that arise from teaching activities of this kind?

Results

The obtained preliminary results of this study show that the school students (92%) did not use the periodic table of elements, the activity series of metals and the solubility table based on the proposed strategy. School students were suppressed this way of learning many items. 87% of teachers have not got experience in teaching how to use them in that way. The periodic table of elements, the activity series of metals and the solubility table are used by teachers during chemistry lessons only in typical way. Teachers emphasized that it is curious and interesting ways to present new content. They belief it is very effective way for remembering new untypical information.

Conclusion

In conclusion, the proper way of using the reference literature chemistry materials help students prepare better for the final exam. It was also shown that both groups of respondents are keenly interested in learning new strategies to use this kind of materials.

References

Nodzyńska, M. (2008). Reading data in a graphic form on the chemistry lesson. M.Nodzyńska i J.R. Paśko (red.), *Badania w dydaktyce przedmiotów przyrodniczych (Research in Didactics of the Science)*. (str. 270-275). Kraków: Uniwersytet Pedagogiczny im. Komisji Edukacji Narodowej.

What and Why – Non-Formal Education of Children in Poland – Possibilities And Experiences

Małgorzata Krzeczkowska, Emilia Grygo-Szymanko,
Paweł Świt, Patryk Własiuk

Jagiellonian University, Faculty of Chemistry, Kraków, Poland
malgorzata.krzeczkowska@uj.edu.pl

Background, framework and purpose

Non-formal education can be described as „learning by doing". It is a lifelong process of shaping attitudes, values, skills and knowledge based on various experiences and educational impact of the environment (family, friends, working environment, playgrounds, markets) and the impact of the mass media. The methodology is based on interaction between learners and the concrete situations they experience. There is usually no teachers or lecturers providing the knowledge ex-cathedra, but the learners and facilitators together provide each other's knowledge and skills in a horizontal relationship. The educator or facilitator may be more or less active in organizing student learning experiences. Such a situation occurs during operation with young people. It is possible to maximize the benefits of non-formal education through the use of various methods, such as peer education, project work, mobility projects, and others.

The growing importance of non-formal education is a direct result of the development of civilization and technology world. Thanks to computers and modern communication, world is changing very quickly and it is necessary to supplement the knowledge of the changes taking place around us. Through various forms of non-formal education soon as we are able to make up the missing knowledge.

The advantage of non-formal education is that it generally does not impose a rigid framework of the learning process (though it is possible, in the case of incorporating the action of courses and training). Very often, non-formal education combined with fun and entertainment, as best seen in edutainment programs. In this way, education is not only useful, but enjoyable for the learner.

Non-formal education in Poland takes various forms and is directed to a group of recipients at very diverse age. Numerous senior clubs, vibrantly working Universities of the Third Age, open museum classes for seniors, the youth and children, science festivals, children's universities, local scientific clubs for the youth and children are few examples of educational activity realized beyond school in Poland.

Methods

Children's thinking is based on perceptive impressions, but they are also capable of abstract thinking (Mareschal & Quinn, 2001), and a lot of researchers additionally postulate children's ability to draw unusually complex causal relationships (Gopnik & Schulz, 2004).In order not to destroy this natural curiosity about the world, a wish to ask questions and make use of children's pursuit to independent cognition of the surrounding world, there appeared an idea of natural science workshops for children at the age of six. Conscious of the existence of so called naive theories shaped by child's own activity, direct experience, environment where they live, we - as the ones who run classes - are aware of the responsibility for the contents, associations and applied analogies we introduce during the classes (Gopnik, 2010). It is obvious that improper activities of teachers, unsuitable words uttered, generalizations created by children, simplifications may contribute to the formation of erroneous convictions, particularly difficult to eliminate.

Findings and conclusions

A lot of international research and reports which deal with the significance and condition of natural sciences in contemporary education indicate that students' commitment and interest in science subjects is shaped first and foremost on the initial educational stages (Osborne & Dillon, 2008). However, here the significance of education taking place at school is clearly underlined. And does the period preceding this formal education remain without significance, does it not have the trait of a learning process? Regarding informal education, realized from the earliest age at home and the nearest surroundings, as the initial educational stage, this is the education which is based on intuitive, spontaneous activities of the youngest children, who make use of senses and research methods (Kuhn, 2002).

On the poster, there will be presented a fragment of classes realized in a group of 320 children aged 7-8 (October – November 2015) shaping and promoting research attitude of children and the results of the survey carried out among the parents of the children participating in our workshop.

In many cases, this type of workshop is the first step to get to know nature on one's own but under the watchful eye of a teacher. This type of classes is a challenge to a cognitive system of pre-school age children but also for those already participating in early school education, particularly when school classes do not arouse natural science interests and do not motivate to gain knowledge. The workshop can engender in children the willingness for further search and broadening knowledge via independent execution of simple experiments at home at parents' presence. The idea of such classes also boils down to making children aware that not always the adults will respond to all their questions or do they know exactly everything and will tell them how to solve a given problem. The workshop is a source of positive emotions, which enable effective and efficient learning of the surroundings.

We believe that learning to be spontaneous, takes place in everyday life and non-formal education is planned and thought through facilitator, trainer or youth worker who also supports the young man at the time the entire learning process.

In parents' opinion these activities gave children the possibilities of creation of active and open-minded attitude in recognition different phenomena in everyday life.

References

Gopnik, A., & Schulz, L. (2004). Mechanisms of theory formation in young children. Trends in Cognitive Sciences, 8, 371-377.

Gopnik, A. (2010). How Babies Think? Scientific American, 7, 76-81.

Kuhn, D. (2002). What is Scientific Thinking, and How Does It Develop? in: Goswami, U. (Ed) Blackwell Handbook of Childhood Cognitive Development. Blackwell (s. 371-393).

Mareschal, D., & Quinn, P.C. (2001). Categorization in infancy. Trends in Cognitive Sciences, 5, 443-450.

Osborne, J. F., & Dillon, J., (2008). Science Education in Europe: Critical Reflections. A Report to the Nuffield Foundation. *King's College London*.

The Polish Biology Olympiad: Analysis of the Students' Research Projects in the Context of the Scientific Method Competence and the Selection of Research Topics

Joanna Lilpop, Marcin M. Chrzanowski

University of Warsaw, Faculty of Biology, Biology Teaching Laboratory, Warsaw, Poland, j.lilpop@biol.uw.edu.pl

Introduction

According to the Polish Biology Olympiad (PBO) statutory regulations in the years 2013-2015, a participant must conduct a research project and send a report which is a criterion allowing for the 2nd and 3rd PBO stages. The student's research project should be an experiment or an observation of biology conducted by the student (ISCED 3) on his/her own – in the field, at home, at school or at other institution (Regulamin Ogólnopolskiej Olimpiady Biologicznej 2014/2015). Each year over 1000 reports from the student's research projects are registered in the competition and a general problem in the quality of students' reports has been observed through the previous editions of the PBO. So the attempt was made to investigate and characterize the problems that students have in the field of scientific method application and to search for the systematic errors that students make. Thus the main aim of the study was to characterize scientific method competences of Polish students taking part in the Biology Olympiad. The analysis of topics of the students' research projects has been conducted as well as identification of systematic errors and deficiencies of the students' experimental works. The results of the survey were used to draw recommendations for students' research projects and the renewed evaluation system for Polish Biology Olympiad.

Materials and methods

Students' research reports from 2014/2015 school year (44 PBO) have been analyzed. The selection of 74 **experimental** students' reports was taken from the storage of 190 best reports accepted by the PBO Central Committee after the 2nd stage of the PBO. The probe covered 15 of 16 regions of Poland and reflected gender structure of the PBO participants after the 2nd stage: 57% of male authors and 43% female authors. The tool for analysis was questionnaire consisted of 40 items filled for all of the analyzed students' reports.

Findings of the survey

Students' choice of research material contain mainly plants (66%), but also animals (24%), microorganisms (7%) and fungi (4%). Most of the topics of all students' works belong to plant physiology (64%) including allelopathy, influence of soil additives to plant growth, effect of electromagnetic field on plants' germination/growth and insolation.

In many posters no straightforward information are given about the source of equipment or place of experiment. In such situation only the context allowed to categorize the information. Analysis shows that 59% of experimental works are conducted at home, 31% in the research institutions and 5% are field-based experiments. The shortest of the experiments last between 4 days and 2 weeks (23% of analyzed reports). The most students' experiments last1-3 months (49%). There are 14% of the most time-consuming experiments that last more than 4 months (up to 390 days!). Students refer predominantly 7-9 literature positions on a report. Total of 662 literature positions were recorded in which 25% is the foreign-language literature (mostly English). 35% of works do not refer to any foreign literature.

Most of the students have confusions about the structure of the report, for example they confuse fragments of results and conclusions, they are not sure where to give the aim of research – either in the abstract or in the introduction. Generally they do not formulate hypothesis for their research (92%). Student create extremely complicated experimental designs: with too many independent and dependent variables which are hard to analyze and rationally discuss. The realistic analysis of experimental quantitative data was confusing because of lack of statistical analysis of collected data (only 7% reports contained statistical analysis including statistical significance tests). Many reports include not enough data on controlled variables, methods or number of test probes so the experiments are not reproducible.

Conclusions

The results of the survey shows that it is recommended to simplify the structure of research projects, decrease the number of variables (independent and dependent) and focus on logic design of the experiment, rational discussion of results and argumentation.

The survey confirms, that PBO regulations and leads for participants needs changes:

– to rise students' awareness in conducting a real research project
– to acquaint students with elements of *How Science Works*
– to rise their self-confidence and competences in the practical part of the International Biology Olympiad
– to uniform the process of research project assessment

So indeed the PBO plans to introduce changes in the school year 2016/17 regulations including: the form of the students' project report; rules regarding the preparation of the project (location where the research can be performed, sample organisms etc.); project preparation schedule and timing; students' reports review system; the manner in which PBO examine students at the final stage of the competition.

Up to September 2016, there will be prepared guides for teachers and their students considering participation in PBO next editions: the special guide on „**how to prepare the research project”**, dedicated for two types of research: based on an biological experiments and based on an observation and the special guide on “**statistical analysis and data handling”**.

Acknowledgments

Authors would like to acknowledge members of Chief Committee of the Polish Biology Olympiad: Piotr Bębas PhD DSc, Łukasz Banasiak PhD and Elżbieta Auguścińska MSc for providing the input data used in our survey.

References

Regulamin Ogólnopolskiej Olimpiady Biologicznej 2014/2015 http://www.olimpbiol.uw.edu.pl/?id_dz=331

Functional Technologic Models of Historical Processing Devices and Their Didactic Use 3. Production of Sugar

Mária Linkešová, Ivona Paveleková, Róbert Knap

Trnava University in Trnava, Faculty of Education,
Department of Chemistry, Slovakia, maria.linkesova@truni.sk

Chemical technological procedures of substances, which are common for pupils (as soap, iron, sugar) can be used as a motivation tool. Coming out of this reason we tried to create simplified models of industrial technologic appliances, which can be used at school for a higher visualisation of a teaching process and enable better, faster and more comprehensive learning. Using these models brings several positive factors: rise of the motivation, activation of the teaching process, explanation of the real industrial production, possibility of opening a pupil interest group, which would by aimed on application of such models into praxis by pupils, application of inter-subject relationships, application of a scientific, visualisation, motivation and activation principles of the teaching process. (Held, 2011). Usage of the technological processes in the teaching process is diverse, alike its use in various stages of the teaching process – for pupils motivation, attention keeping, as a problem task solving, presentation of a new knowledge, during repeating. Some of them can be also applied as a project, the simpler ones also as a laboratory work.

We have chosen the historical procedures, demonstrating the chemical process more simple, because the historical devices and working technologies were easier to execute than recent industrial technologies. This work is the third one of the series of papers dealing with the didactic use of the functional technologic models of historical processing devices. The previous ones concerned the production of the soap (Linkešová, 2011) and the iron (Linkešová, 2012).

Our next „production“ object – beet sugar (saccharose) is a substance, which we meet at each step in our everyday life.

The technological procedure of the sugar beet processing to the final product – saccharose is elaborated in three individual teaching units with the short fourth stage, by which a final product isolation would be realised: the extraction of sugar from beet to form a sugar solution, removing the beet impurities out of the sugar solution, water evaporation and crystallising the sugar. Therefore it can be realised as a series of consecutive laboratory works. This technological model can be used in chemistry classes in the 9th grade of basic schools, 4th grade of grammar schools and the 3rd grade of total secondary education schools within the topic of Carbohydrates.

Preparation the set of documents for teachers and pupils containing basic information about the sugar beet and its processing in industrial conditions is one part of the paper. Each teaching units contains working instructions for pupils, methodical instructions and technical notes for teachers.

1st Stage: Extraction and diffusion of the sugar solution from the beet

Cleaned and washed sugar beet (minimal weight 500 g) is weighted and grated at a food grater. Grated beet pulp is put into a pot and poured by warm water (app. 1 dm^3). Pulp must be submerged. We note the used volume of water. Mass is being heated on an electric cooker. We observe the water temperature; it cannot exceed 70 °C. Little by little we add a solution of the sulphuric acid (50 cm^3 for 1 dm^3 of juice), while we watch the pH value of the solution (raw juice) using an universal indicator paper (must be in range of 4 – 5). Approximately after 30 minutes of heating and stirring, we filtrate the raw juice into the beaker through a kitchen sieve. Its colour should be yellow-brown. We check the volume of the solution and if it is needed, we add water. The volume of the solution must be the same as the input volume of the extraction eater.

2nd Stage: Purifying of the sugar solution – epuration

We prepare a milk of lime in a beaker by stirring the calcium oxide CaO in a distlled water (for 1 dm^3 of a raw juice we use 2 g of CaO in 25 cm^3 of water). Milk of lime is being added into a beaker with the raw juice during stirring and heating for temperature between 84 – 93 °C. We check the pH value of the sugar juice; it should be within the range of 10 – 11. Afterwards we start to blow the carbon dioxide into the solution by a straw. Bubbling the carbon dioxide is being realised at least for 15 minutes with short breaks. Juice is being stirred meanwhile. Clots from the hot juice will be filtered. When an air pump is available, we use the vacuum filtration, but also a simple filtration through a pleated filter paper is suitable. We should gain a light-yellow solution – the light juice.

3rd Stage: Evaporation of the solution, crystallization

The light juice is poured into a beaker or a pot and is being heated carefully. We check the juice temperature not to exceed 85 °C, otherwise the sugar would caramelise. By evaporating the water, the juice is thickening (or the concentration is increasing). We keep the evaporation until the sugar juice is sticky and very viscous. We insert few sugar crystals into the juice and we let it crystallise freely at a window sill for 3 – 4 weeks. We cover the pot by a filter paper or a cloth to avoid dust and we do not move it anymore. Tiny white crystals of a saccharose will appear in the thick brown syrup. We can isolate the crystals from the syrup (molasses) by a centrifuge, or by a kitchen rotation juicer.

Acknowledgements

This contribution is supported by Ministry of Education of the Slovak Republic through the project KEGA 003TTU-4/2016 *Chemistry and Society*.

References

Held, Ľ., Žoldošová, K., Orolínová, M., Juricová, I. & Kotuľáková, K. (2011). *Výskumne ladená koncepcia prírodovedného vzdelávania (IBSE) v slovenskom kontexte*. Trnava, Slovakia: Trnavská univerzita v Trnave, Typi Universitatis Tyrnaviensis.

Linkešová, M. & Kurusová, H. (2012). Funkčné technologické modely historických výrob a ich didaktické využitie. 2. Výroba mydla. *Aktuálne trendy vo vyučovaní prírodných vied.* Trnava: Pedagogická fakulta, Trnavská univerzita v Trnave, 2012, 289-294. (Zborník z medzinárodnej konferencie. Smolenice 15 – 17 Oct. 2012)

Linkešová, M. & Worobelová, M. (2011). Funkčné technologické modely historických výrobných zariadení a ich didaktické využitie. 1. Šachtová pec na výrobu železa. *Biologie, chemie, zeměpis*. 2011, 20(3x), 84-88. (*Chemické vzdělávání v teorii a praxi*. Materiály z mezinárodní konference o výuce chemie. Plzeň, 15 – 17 June 2011)

Small Experimental Projects in Preservice Science Teachers´ Professional Development or Let´s Use our Heads to Play

Veronika Machková, Michaela Křížová, Barbora Uždilová

Faculty of Science, University of Hradec Králové, Czech Republic
veronika.machkova@uhk.cz, michaela.krizova@uhk.cz, barbora.uzdilova@uhk.cz

Introduction

Curricular changes within the primary and secondary schools requires new approaches to teaching science subjects. Project method, which is characterized by high degree of complexity, interactivity and autonomous work within cognitive activities, is one possible solution. The process of forming knowledge throw the project method can be a chance of complex development of the personality in many aspects. This method can also have a crucial role in development of key competences (Rusek & Dlabola, 2013, Nodzyńska, 2015). Therefore, the Project-Oriented Approach is implemented to the study programme of preservice science teachers at Faculty of Science, University of Hradec Kralove (Bílek & Machková, 2014).

Challenging environment for project activities

Practical application of project method is part of courses focused on school experiments and its purpose is to develop pedagogical skills of preservice science teachers. The projects preparation and realization runs during the summer semester and the incentive for project activity is participation of our students at the two-day open-air educational event Let´s use our head to play focused on science popularization (Machková, Bílek & Křížová, 2016).

This event is organized every year in June since 2008 by the Faculty of Science, University of Hradec Kralove and it is devoted especially for primary and secondary school pupils, however every visitor is welcomed (Křížová, Česáková & Šlégr, 2015). There are always prepared many stands where traditional and non-traditional physics, chemistry, biological and mathematical experiments are presented. The important parts of the programme are the engaging lectures as well as the entertaining and instructive competitions. This real situation promotes students´ interest and increases students´ motivation to prepare their presentation.

The project preparation runs during the whole summer semester following the "four-level plan", which was presented by Demuth in 1991 (Ganajová et al., 2010). Demuth´s four levels are (1) Incentive and motivation, (2) Joint planning,

(3) Realization and presentation of the project, (4) Evaluation of results. The real situation, which formed framework of project processing increases students´ motivation in working on the project task (ad 1), and it is near of their future situation in the school. The joint planning (ad 2) starts on the first seminar of semester and its aim is to find the consensual concept of project realization and set the timetable for partial task of realization and control days. Each year the event has a different topic, for example Fairy-tale Science (2014), Infinity (2015), Duel of Elements (2016), and students have to adapt their educational presentation of experiments to these topics.

Realization and evaluation of group work on the project

In the process of realization (ad 3) students solve many partial tasks – scenario of educational presentation, choice of experiments, training of captivating demonstration, preparation of didactic materials, preparation of material support of experiments, costume and scenery and role play of group´s members. They solve partial tasks throughout the whole semester and discuss their progress at seminar during scheduled control day.

In the center of interest is traditional or non-traditional physics, chemistry, biological and mathematical experiments presentation. The important part of the presentation is engaging pupils in making experiments. Every presented experiment is accompanied by handouts with tasks to solve, solution of tasks and written description on the very understandable level. Usually the task and its solution are on different sides so that pupils really have to think about it. Very often, students choose popular experiments for their presentation, for example fire magic, blue bottle, experiments with liquid nitrogen or dry ice, optical illusions, giant bubbles, Bengal fire, experiments with sound, magnets and electricity or color changes of red cabbage juice. Depending on the risk of accident of chosen experiment, it is designed for pupils´ experimentations or not, in the case of high level of risk experiments are only demonstrate by our students.

At the end of the semester, students demonstrate final version of their educational presentation at seminar to other group and peer evaluation of presentations (ad 4) through the SWOT analysis is executed to eliminate possible imperfections. Within the evaluation students discover strengths, weaknesses, opportunities and threats of their presentations and reflecting the results students adjust and finalize their presentations for the two-day open-air educational event Let´s use our head to play.

Conclusion

Implementation of Project-Oriented Approach to the study programme of preservice science teachers at Faculty of Science, University of Hradec Kralove provide positive impact. First, students have opportunity to independently prepare small educational presentation supported by experiments and verify its efficiency in interaction with the primary and secondary school learners, which has positive impact on their pedagogical skills development. And second, they practically try out work on the project during the whole semester, so they can assimilate very good methods of work in project-oriented approach of learning and teaching.

Acknowledgements

This paper is supported by the Specific Research Project N°2120/2016 of Faculty of Science, University of Hradec Kralove.

References

Bílek, M., & Machková, V. (2014). Inquiry on Project Oriented Science Education or Project Orientation of IBSE? In M. Rusek, D. Stárková & I. Metelková (Ed.), Project Based Education in Science Education (1st ed., pp. 10 - 20). Charles University in Prague, Faculty of Education. WOS:000357160200001.

Ganajová, M., Kalafutová, J., Müllerová, V., & Siváková, M.. (2010). Projektové vyučovanie v chémii. Bratislava: Štátny pedagogický ústav.

Křížová, M., Česáková, J., & Šlégr, J. (2015). Hrajme si i hlavou. Hrajme-si-i-hlavou.cz. Retrieved 29 November 2015, Retrieved from http://www.hrajme-si-i-hlavou.cz/

Machková, V., Bílek, M., & Křížová M. (2016). Project-oriented approach in professional development of future teachers or Let´s use our heads to play. In M. Rusek (Ed.), Project Based Education in Science Education XIII (1st ed., pp. 24 - 29). Charles University in Prague, Faculty of Education. WOS: 000375780600003.

Nodzyńska, M. (2015). Metoda projektów czy PBL? In M. Nodzyńska & W. Kopek-Putala (Ed.), Co w dydaktykach nauk przyrodniczych ocalić od zapomnienia? (1st ed., pp. 100 - 112). Uniwersytet Pedagogiczny w Krakowie. ISBN:978-83-7271-967-6.

Rusek, M., & Dlabola, Z. (2013). What is and what is not a project? In M. Rusek & V. Köhlerová (Ed.), Project-Based Education in Chemistry and Related Fields (1st ed., pp. 15 - 21). Charles University in Prague, Faculty of Education. WOS:000339813900002.

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

Veronika Machková[1]; Kateřina Chroustová[1]; Pavla Hanzalová[2]

Faculty of Science[1], Faculty of Education[2], University of Hradec Králové, Czech Republic, veronika.machkova@uhk.cz, katerina.chroustova@uhk.cz, pavla.hanzalova@uhk.cz

Introduction

The use of mobile technologies is becoming increasingly habitual in education at all of levels. The learning supported by mobile technologies is called "mobile learning" or "M-learning" (Rosman, 2008). There are many ways how to use these technologies in lessons. Usually, they can be used as source of information, exercises or test machine, communication tool, etc. (Goodwin, 2012). They can have a specific use as support of laboratory work in science education (Stárková & Rusek, 2015, Glavinic, Kukec, & Ljubic, 2007).

We focused on the case of mobile technology supporting chemistry laboratory work. We let pupils at lower secondary school level use tablets as means to make video records of experiments performed during lessons of chemistry laboratory work. Moreover, we made inter-subject connection with IT lessons, where obtained video records were edited and subtitled to get video protocol of realized laboratory work. We thought that this new educational situation increases pupils´ motivation and enhances understanding of science topic through the planning of a sequence of scenes for video recording. We tried to find and adjust optional conditions of organization for the pupils in five laboratory workshops, which were performed successively (Chroustová, Machková, & Hanzalová, 2016, Hanzalová, Chroustová, & Machková, 2016).

Case study description

Our case study focused on the influence of different organizational conditions of pupils´ work on video records of experiments, on its quality and on effectiveness of pupils´ work. Altogether, 29 pupils of the fourth class of eight-year grammar school (pupils aged 14-15) took part in this case study, who we followed in five laboratory workshops supervised by their Chemistry teacher with long-time experience and in two IT lessons where preparation before the shooting itself and final adjustment of the videos was held. The pupils were divided into two balanced groups. The groups worked under different organizational conditions. We progressively tried influence of this situations: (1) No special instruction or preparation. (2) Special instructions for recording. (3) Special instructions for recording and script of video record preparation. The sequence of all particular steps of the case study is shown in the scheme in Figure 1.

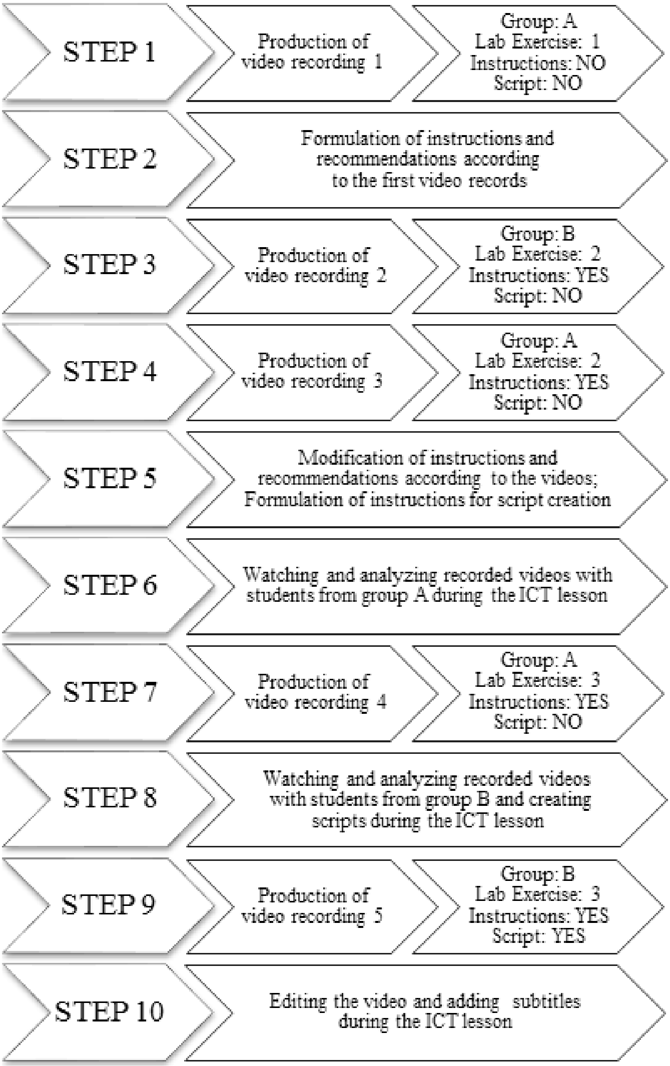


Figure 1. Scheme of Process of Case Study (Hanzalová, Chroustová, & Machková, 2016)

We used the method of structured dialogue between the teacher and the pupils and the analysis of pupils´ products - video records as well as the scripts during the case study.

Analysis of pupils´ video records showed that adjustment of organizational conditions has positive influence on pupils´ results. Video records obtained in situation (1) were poor quality from technical and content point of view. Situation (2) influenced especially technical quality of video records and situation (3) ameliorate technical quality and content quality of video records. We could find out from structured interview higher pupils´ motivation and interest to solve this task caused by inter-subject connection with IT lessons.

Conclusions and implications

Let pupils make records of chemical experiments during laboratory workshops is one of the chances how to use modern mobile technologies while teaching Chemistry. This unusual educational situation can increase motivation and promote more interest in laboratory work. But this effect is not made through the implementation of mobile devices to the ordinary task, it is made primarily through the appropriate adjustment of organizational conditions. Our case study shows that this use of mobile technologies supported by appropriate adjustment of organizational conditions shall lead to the higher level of integration of ICT technologies into education in context of Goodwin´s SAMR model of technology integration (Goodwin, 2012).

Acknowledgementa

This paper is published thanks to the financial support of Specific Research of Faculty of Science University of Hradec Králové Nr. 2120/2016 and Specific Research of Faculty of Education University of Hradec Králové Nr. 2140/2016.

References

Chroustová, K., Machková, V., & Hanzalová, P. (2016). Towards the Implementation of Mobile Technology into the Experimental Chemistry Education. In Turčáni, M., Balogh, Z., Munk, & M., Benko, Ľ. (Eds.), *DIVAI 2016 – 11th Internacional Scientific Conference on Distance Learning in Applied Informatics: Conference Proceedings* (pp. 121–135). Prague: Wolters Kluwer. Retrieved from: http://konferencie.ukf.sk/public/conferences/1/schedConfs/19/Divai2016.pdf

Glavinic, V., Kukec, M., & Ljubic, S. (2007). Mobile Virtual Laboratory: Learning Digital Design. In *2007 29th International Conference on Information Technology Interfaces* (pp. 325–332). IEEE. doi: 10.1109/ITI.2007.4283791

Goodwin, K. (2012). Use of tablet technology in the classroom. *NSW Department of Education and Communities*. Retrieved from: http://rde.nsw.edu.au/files/iPad_Evaluation_Sydney_Region_exec_sum.pdf .

Hanzalová, P., Chroustová, K., & Machková, V. (2016). Implementation of

Mobile Technology into the Experimental Chemistry Education. Manuscript submitted for publication.

Rosman, P. (2008). M-learning-as a paradigm of new forms in education. *E+ m ekonomie a management*, (1), 119. Retrieved from: www.ekonomie-management.cz/download/.../13_rosman.pdf

Stárková, D., & Rusek, M. (2015). The Use of M-Technology in Proglem, Inquiry and Project-based Learning. In Rusek, M., Stárková, D., & Metelková, I. (Ed.), *Project-based Education in Science Education XII.*, Praha (pp. 85–91). Praha: UK PedF. Retrieved from: http://pages.pedf.cuni.cz/pvch/files/2011/11/PBE2014.pdf

3D Printed VSEPR Models and 3D Periodic Tables for Chemistry Education

Luděk Míka, Petr Šmejkal

Faculty of Science, Charles University in Prague, Albertov 6, 128 43 Prague 2, Czech Republic, lumec.obecny@gmail.com, psmejkal@natur.cuni.cz

Introduction

3D printing is an additive technology used for three-dimensional object creation. First 3D printer was patented by Alain Le Méhauté, Olivier de Witte and Jean Claude André in 1984. There are multiple types of 3D printers depending of technology used. The first 3D printers were/are based on UV light photopolymerization of thin layers of light-sensitive resin. This process is known as stereolithography (SLA). Another method of 3D object fabrication is sintering of powdered materials like plastic, metal or plaster. 3D printers based on fused deposition fabrication (FDM) process are the most common. Main principle of this process is extrusion and deposition of melted plastic on bed. SLA process is best for making small and precise object, processes using powder bed are best for colorful objects and complex objects.

3D printing is a very promising tool for teaching aids manufacturing. These aids can better reflect the teachers´ teaching aims than aids available commercially, in addition to that, the spectrum of aids can be wider. Nowadays, the price of the technology is in many cases at acceptable level and Czech teachers can have 3D printer at their school. Many publications which deal with 3D printing of various teaching aids for chemistry have appeared recently (for example Rodenbough et al (2015), Rossi et al (2015) or Lolur et al (2014), nevertheless, new approaches for printing of 3D objects are still needed due to variability of the possibly printed objects (aids) and differences in 3D printers and 3D printing methods. Hence, the number of didactic models of teaching aids for 3D printing is still limited and preparation of new models is often behind teachers´ possibilities due to some aspects which complicate the process of 3D printing. With respect to that, in this contribution, a possible, parametric, approach for creation of relatively simple 3D models design and generation is suggested and discussed. The models which benefit well from this method of model preparation are 3D periodic tables, which are very illustrative tools for demonstration of differences in properties among various elements in periodic system (Fig. 1). In these models, height of bar representing the element represents a quantity of the element property. Also models for teaching VSEPR (Valence shell electron pair repulsion) approach to determine shape of molecules (Fig. 2) can be prepared by the mentioned way and their preparation will also be discussed.

Figure 1. Model for 3D printing of 3D periodic table

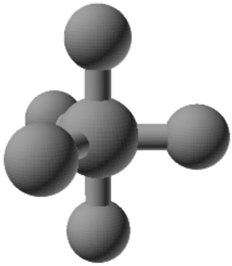


Figure 2. VSEPR model for 3D printing (trigonal bipyramide)

Approaches for printing of 3D models

Our attempts and optimization of the printing process showed that employment of CAD-like OpenSCAD freeware software using parametric generation of the models is very effective way for 3D printing of 3D periodic tables and 3D VSEPR models of basic shapes of molecules. The mentioned approach for both of these models showed also a possibility of simple export and additional changes in these models, for example height of the columns (3D periodic table) or atom radii, bond length etc. in the VSEPR models. This approach thus allows to generate and print relatively high number of various models of 3D periodic tables and VSEPR models.

In more detail, the models were programmed using freeware C language based software OpenSCAD for model design according to software manual (Kintel et al., 2016). The created code allowed us simple changes in parameters of the models. Consequently, the models were exported in the OpenSCAD software into *.stl file, which is accepted by majority of common cheap FDM (Fused Deposition Modeling) printers. Through slicing software (Slic3r), the models were converted to *.gcode and printed by FDM 3D printer. Using this approach, 3D printed periodic tables representing the following properties were modeled and printed: Density, Melting point, Boiling point, Abundance, Electronegativity, Atomic radius, Year of discovery and Atomic mass. Properties of the elements were taken from various (IUPAC) databases. In the case of VSEPR models, all the basic shapes were programmed, modeled and printed from linear to bipyramidal shapes. These models were distributed among Czech teachers and also uploaded to well-known and often used www.thingiverse.com database, where they are available for teachers (users) to print and employ in their teaching lessons.

Conclusions

An approach using a parametric generation of the models in the OpenSCAD software for creation and 3D printing of models of 3D periodic tables representing and comparing various properties of elements and VSEPR model basic shapes were suggested and tested. It was shown that the described approach is very effective and versatile method for generation of variety of models and shapes with possibility of simple changes in model properties (for example height of the bar in 3D periodic table or change of electron pair for bond (and vice versa) in VSEPR models. It was also shown that preparation and 3D printing of some teaching aids can solve problem with expensive or not available aids at the Czech market as 3D printing using the described method showed to be relatively simple and cheap method for teaching aids preparation. Set of 3D printable periodic tables as well as the VSEPR models have been made and uploaded to www.thingiverse.com database, where they are quite successful (3D periodic tables - 618 downloads, VSEPR models - 222 downloads). The printed models are also very positively evaluated by the teachers who obtained any of these models.

Acknowledgements

The support of the Faculty of Science, Charles University in Prague and project PRVOUK P42 is gratefully acknowledged.

References

Lolur, P., Dawes, R. (2014). 3D Printing of Molecular Potential Energy Surface Models, *J. Chem. Educ.* 91, 1181 - 1184.

Kintel, M. et al. (2016) OpenSCAD - The Programmers Solid 3D CAD Modeller, OpenSCAD User Manual [online]. [cit. 2016-08-21]. Available from: http://www.openscad.org/documentation.html

Rodenbough, P. P., Vanti, W. B., Chan, S-W. (2015). 3D-Printing Crystallographic Unit Cells for Learning Materials Science and Engineering, *J. Chem. Educ.* 92, 1960 – 1962.

Rossi, S., Benaglia, M., Brenna, D., Porta, R., & Orlandi, M. (2015). Three Dimensional (3D) Printing: A Straightforward, User-Friendly Protocol To Convert Virtual Chemical Models to Real-Life Objects, *J. Chem. Educ.* 92, 1398 - 1401.

Sustainable Development in Chemistry Textbooks at ISCED3 Level

Małgorzata Musialik[1], Marcin M. Chrzanowski[1,2], Irmina Buczek[1], Barbara Ostrowska[1]

[1]School Subject Teaching Unit, Educational Research Institute
[2]University of Warsaw, Faculty of Biology, Warsaw, Poland
m.musialik@ibe.edu.pl

Introduction and Aims

Sustainable development is a process whose aim is to meet "the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). One of the priorities of education for sustainable development (ESD), both in global and local dimension, is to increase the efficiency of environmental education at all levels of education through a variety of activities that foster the acquisition of knowledge about the natural environment and the protection of its resources, as well as the formation of pro-environmental attitudes (Cichy, 2005, Tuszyńska, 2010). Multidisciplinary ESD requires a comprehensive, holistic and well thought-out curriculum and textbooks that will provide learners with the skills and knowledge necessary for sustainable development of individuals.

– Investigation of sustainable development issues included in the core curriculum for chemistry at ISCED 3 level

– Implementation of sustainable issues required by chemistry curriculum in various chemistry textbooks for senior high schools (ISCED 3 basic level)

Methods

The subject of this research were elements related to sustainable development and environmental education occurring in the provisions of the chemistry curriculum [www.1] for ISCED 3 basic level and the content of corresponding chemistry textbooks, including: quantitative and qualitative characteristics of graphical material, questions, tasks and repetitive material. Textbooks were selected based on the List of textbooks approved for school use for general education, taking into account the new core curriculum for pre-school education and general education in particular school types, published on the Ministry of National Education's website [www.1]. At the time of the study seven chemistry textbooks for ISCED 3 basic level were available. The analysis of these textbooks was carried out by science specialists from the Educational Research Institute (ERI) (textbooks coded from S01 to S04) in cooperation with ERI's external expert (textbooks coded from S05 to S07). The study of textbooks was performed based on modified Niaz's method (Niaz, 1998). The chemistry textbooks, which were part of this analysis, are listed in table 1.

Table 1. List of chemistry textbook assessed in the study.

Chemistry textbooks for ISCED 3 basic level		
Code	Title	Authors
S01	*Chemia. Po prostu.* Podręcznik dla szkół ponadgimnazjalnych. Zakres podstawowy. Wydawnictwo: WSiP	H. Gulińska, K. Kuśmierczyk
S02	*Chemia.* Zakres podstawowy. Podręcznik dla szkół ponadgimnazjalnych. Wydawnictwo Pedagogiczne OPERON	J. Meszko
S03	*To jest chemia.* Podręcznik dla szkół ponadgimnazjalnych. Zakres podstawowy. Wydawnictwo: Nowa Era	R. Hassa, A. Mrzigod, J. Mrzigod
S04	*Chemia na co dzień.* Podręcznik do szkół ponadgimnazjalnych. Zakres podstawowy. Wydawnictwo: Oficyna Edukacyjna Krzysztof Pazdro	K. Pazdro, R. Szmigielski
S05	*Chemia.* Zakres podstawowy. Podręcznik dla szkół ponadgimnazjalnych. Wydawnictwo Pedagogiczne OPERON	A. Sikorski
S06	*Świat chemii.* Podręcznik dla szkół ponadgimnazjalnych. Zakres podstawowy. Wydawnictwo „Zamkor"	I. Maciejowska, A. Warchoł
S07	*Chemia.* Podręcznik dla szkół ponadgimnazjalnych. Zakres podstawowy. Wydawnictwo Edukacyjne „Żak"	B. Kałuża, F. Kamińska

Results

The sustainable development issues in the core curriculum for chemistry at ISCED 3 basic level are presented in the table 2. The elements of environmental content in textbooks are shown in the table 3.

Table 2. The sustainable development issues in the curriculum for chemistry at ISCED 3 (MEN, 2009).

Curriculum module	Teaching content – detailed requirements	
Module 2. Chemistry of cleaning agents	2.3	Student explains the reason for the elimination of phosphates(V) from the composition of washing powders (eutrophication process).
Module 4. Soil chemistry	4.3	Student lists the sources of chemical contamination of soils and the basic types of contaminants (heavy metals, hydrocarbons, pesticides, nitrates).
	4.4	Student proposes the ways of protecting soil from degradation.
Module 5. Fuels – at present and in the future	5.4	Student proposes the alternative sources of energy – analyzes the possibilities of their applications (biofuels, hydrogen energy, solar power, water power, nuclear power, geothermal, etc.).
	5.5	Student analyzes the influence of different ways of getting the energy on the state of natural environment
Module 6. Chemistry of packaging and clothing	6.2	Student classifies plastics according to their properties (thermoplastics and thermosets); writes equations of the chemical reaction for the synthesis of the PVC, indicates risks of gases generated by the combustion of the PVC.
	6.3	Students justifies the need for the management of waste from various packaging.

Table 3. The elements of environmental content in analyzed textbooks with corresponding requirements of core curriculum for chemistry at ISCED 3 basic level.

CURRICULUM MODULES	TEXTBOOKS																				
	S01			S02			S03			S04			S05			S06			S07		
	Coh.[a]	Pics[b]	Q[c]	Coh.[a]	Pics[b]	Q[c]	Coh.[a]	Pics[b]	Q[c]	Coh.[a]	Pics[b]	Q[c]	Coh.[a]	Pics[b]	Q[c]	Coh.[a]	Pics[b]	Q[c]	Coh.[a]	Pics[b]	Q[c]
MODULE 2. Chemistry of cleaning agents																					
2.3. Student explains the reason for the elimination of phosphates(V) from the composition of washing powders (eutrophication process).	R	1	3	R	1	1	R	2	2	R	1	1	R	3	2	R	4	7	Z	1	0
Module 4. Soil chemistry																					
4.3 Student lists the sources of chemical contamination of soils (…)	R	4	1	R	6	1	R	2	0	R	3	2	R	4	2	R	7	4	Z	1	1
4.3 (…) and the basic types of contaminants (heavy metals, hydrocarbons, pesticides, nitrates).	R	4	3	R	3	1	R	1	0	Z	4	1	R	9	9	R	2	3	Z	0	2
4.4 proponuje sposoby ochrony gleby przed degradacją	R	3	1	R	3	2	R	1	3	R	2	1	R	0	2	R	3	4	Z	1	3
Module 5. Fuels – at present and in the future																					
5.4. Student proposes the alternative sources of energy – analyzes the possibilities of their applications (biofuels, hydrogen energy, solar power, water power, nuclear power, geothermal, etc.).	R	11	3	R	20	8	Z	1	0	R	10	1	R	11	5	R	30	19	Z	9	4
5.5 Student analyzes the influence of different ways of getting the energy on the state of natural environment.	R	3	1	R	8	8	R	5	3	R	3	1	R	9	7	R	5	3	W	0	4
Module 6. Chemistry of packaging and clothing																					
6.2 Student classifies plastics according to their properties (thermoplastics and thermosets); (…)	R	0	2	R	2	0	R	3	1	R	3	0	R	1	3	R	1	3	R	1	0
6.2 (…) indicates risks of gases generated by the combustion of the PVC.	R	1	1	R	0	1	W	0	0	R	2	1	W	0	2	Z	1	3	*n*	0	0
6.3 Students justifies the need for the management of waste from various packaging	R	3	1	R	1	2	Z	0	0	R	1	0	Z	2	0	R	1	2	Z	0	0

Where: [a] **Coh.** – *coherence;* [b] **Pics** – *number of illustrations;* [c] **Q** – *number of related questions or tasks. The following assessment notes were possible:* **R** – *extended, if the certain element of core curriculum was discussed in details, or even exhaustively;* **Z** – *concise, if the element of core curriculum has been discussed briefly, but sufficiently;* **W** – *slightly mentioned, if the issue has been discussed too general or just mentioned;* ***n*** – *absent, if the issue in the textbook was not mentioned at all.*

Caution: *some illustrations and questions were counted more than once as they were related to more than one item.*

Conclusions

The provisions related to sustainable development, which were found in the core curriculum for chemistry (ISCED 3 basic level), have not mentioned directly the concept of sustainable development, and concerned essentially environmental issues, i.e. sustainable use of natural resources, climate change, development of agriculture and disaster prevention or mitigation.

Most of mandatory topics analyzed in this study had extensive (R) or concise (Z) description in all examined textbooks. We have noticed only few cases in which the obligatory issue was omitted (p. 6.2 in S07) or slightly mentioned (p. 6.2 in S03 and S05, p. 5.5 in S07). Some mandatory topics were commented very shortly (e.g. gases generated by the combustion of the PVC) and others were discussed extensively, filled with illustrations and various tasks to solve (e.g. fuels and alternative sources of energy).

References

Cichy, D. (ed.) (2005). Edukacja środowiskowa wzmocnieniem zrównoważonego rozwoju. Warszawa: Instytut Badań Edukacyjnych, Wyższa Szkoła Pedagogiczna ZNP.

MEN (2009). Podstawa programowa z komentarzami, T.5. Edukacja przyrodnicza w szkole podstawowej, gimnazjum i liceum; przyroda, geografia, biologia, chemia, fizyka. Warszawa: Ministerstwo Edukacji Narodowej.

Niaz M. (1998). From cathode rays to alpha particles to quantum of action: A rational reconstruction of structure of the atom and its implications for chemistry textbooks. Science Education 82: 527–552.

Tuszyńska, L. (ed.) (2010). Edukacja środowiskowa w społeczeństwie wiedzy. Warszawa: Wydział Biologii Uniwersytetu Warszawskiego.

World Commission on Environment and Development (1987). Our Common Future. Oxford University Press. Oxford.

[www.1] http://www.men.gov.pl/podreczniki/dopuszczone_lista1.php?file=gimnazjum)

Codes With Variable Bit-Length and Their Didactic Models

Michal Musílek

Department of Informatics, Faculty of Science, University of Hradec Králové

Modeling and Simulation in education

Modeling and computer simulation can be understood as new methodology not only in scientific research but also in educational process – see e.g. Hubálovská and Hubálovský (2013). Using the method of modeling and computer simulation helps pupils or students formulate problems, understand the principles of the problems and solve the problems – see e.g. Hubálovská and Hubálovský (2016).

Codes with variable bit-length and their use in wireless communication

In the context of informatics education in secondary schools, pupils often acquaint themselves with coded text information using codes with a fixed bit-length. Typical examples are ASCII (American Standard Code for Information Interchange) with length 7 bits and ITA-2 (International Telegraph Alphabet No. 2) with length 5 bits.

However, in modern systems of character encoding, such as family of Unicode codes, we use as a fixed bit length systems (e.g. ... UTF-32 code length 32-bit) as variable bit-length systems (e.g. UTF-8, which, however, is best optimized in the point of view memory consumption, fault tolerance, and backward compatibility with ASCII). Family of Unicode codes are not suitable as tutorials for its complexity, especially at the lower secondary school.

Much better examples are the codes used for remote wireless transmission of information, such as Morse code or Varicode. Inventor Samuel F. B. Morse developed his telegraph code in 1838. Method of determining the speed of transmission in Morse code is called PARIS. The word PARIS is the standard because it consists exactly from 50 elements (50 bit of information). Each dit (dot) is transmitted with one element, each dah (dash) is transmitted with three elements. Intra-character spacing equals one element, inter-character spacing equals three elements and inter-word spacing equals seven elements -see Figure 1.

Lengths of individual characters (letters, numbers, signs) are different in Morse code, therefore also total lengths of different words are different. In Figure 1 is added a second word KRAKOW. This word has six letters, but the total length is 72 bits, not 60 bits. So average length of letter is 10 bits for PARIS, but 12 bits for KRAKOW. By the way average length 12 bits is more realistic for plain English text then 10 bits.

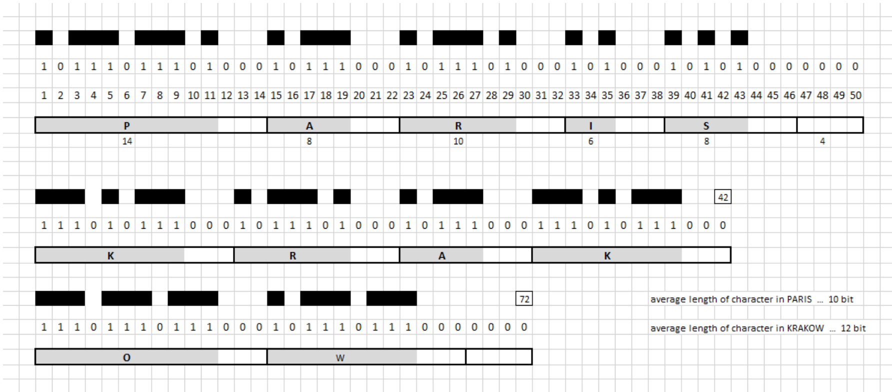


Figure 1. Bit representation of Morse code.

Let us focus is on Varicode now. Varicode is a special case of the Huffman codes, which is used for PSK transmitting on amateur radio bands. Huffman coding is commonly used for lossless data compression. Their main advantage is minimal redundancy resulting code. The difference between using Morse code and Varicode in practice is in the way of receiving and modulation. Morse code is typically used for on-off switching in CW mode (Continuous Wave) and it is received by ears of trained radio operator, whereas Varicode is used in PSK mode (Phase Shift Keying) and it is received by computer. Computer sound card is very important in this process, so when you are receiving it is possible to distinguish many different durations in Varicode signal, not just two (dit and dah) as in Morse code. See example on Figure 2.

In fact, there are several different types of PSK, but figure 2 shows the simplest, called BPSK (Binary Phase Shift Keying), which modulates the signal as follows: If the input binary digit is 1, the phase of signal is not changed. If the input binary digit is 0, the phase is changed to antiphase, i.e. rotated 180 degrees.

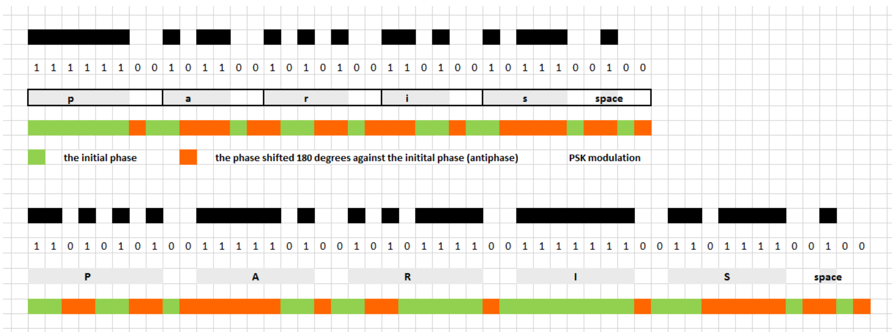


Figure 2. Bit presentation of Varicode and PSK signal modulaton.

Individual characters in Varicode consist by chaining segments 1 or the 01, but the first digit must be 1. Each character in transmission connects as suffix the segment 00 expressing the gap between characters.

Visualisation of the Morse code and varicode

It is appropriate to show to students as an incentive for visualization broadcast messages via Morse code signal that form, which is used in practice. This is an audible signal, e.g. on webpage http://lcwo.net/en/text2cw.

The students' task is to program a visualization of Morse code generating in the form of macros in Visual Basic for Applications. The transmitted signal will simulated by filling the corresponding cells in spreadsheet, similarly in Figure 1. Analogously, it is possible submit task visualize transmitting Varicode similarly in Figure 2.

The students' task was also appropriate manner easily visualize the process of decoding information received from a radio band to plain text. They use tool GraphViz which generates graphs automatically based on a simple description of nodes and edges (Fig 3, Fig. 4.).

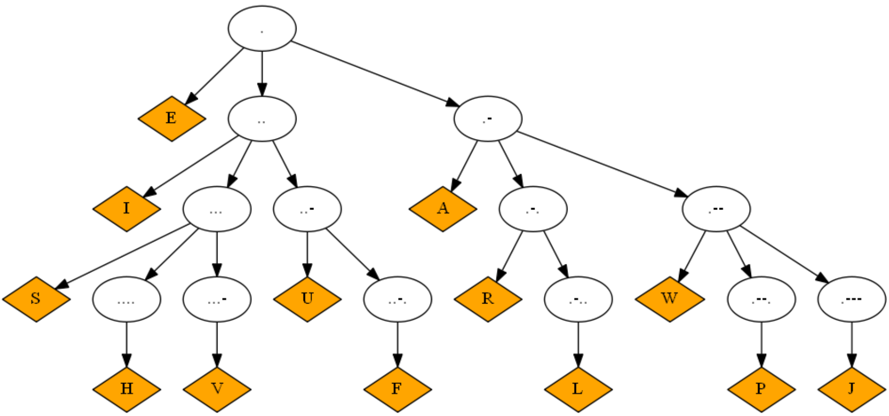


Figure 3. Graph (tree) analysing Morse code – letters starting with sound dit.

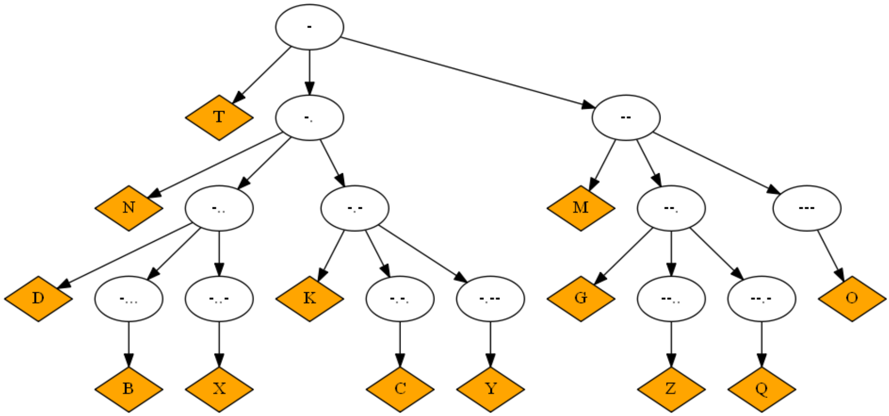


Figure 4: Graph (tree) analysing Morse code – letters starting with sound dah.

Conclusion

The presented case study of the creation of mathematical model and computer simulation were examined during the learning of high students in the study program Computer Support of Archives in subject Programming. The using the modeling and simulation method in learning of humanities-oriented study program support understanding of the students in the computational area and develops their logical thinking. The similar models and simulations will be used even in the learning of programming in other study programs.

References

Hubálovská, M., Hubálovský, Š., (2013). Implementation of the Systems Approach in Mathematical Modeling, Dynamic Simulation and Visualization Using MS Excel Spreadsheet". *International Journal of Mathematics and Computers in Simulation*, Vol. 6, No. 2.

Hubálovská, M., Hubálovský, Š., (2016). Learning Method for Development of Discovering and Creativity of Pupils and Students in Basic Education. *International journal of education and information technologies*. Vol. 10. North Atlantic University Uunion.

Implementation of a Sustainable Development Program as an Ecological Teaching and Educational Tool

Gayane S. Nersisyan, Mariam A. Grigoryan

Center for Ecological-Noosphere Studies of the National Academy of Sciences, RA
gayane.nersisyan@cens.am; ga_ushik@rambler.ru

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. 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 "multistory" 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, 2015; Vasilenko, 1995; www.ncsd.am).

Yerevan is an industrial center experiencing the load of intense construction and heavy traffic. 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. Green urban spaces are extremely important as urban plants have a property to absorb large quantities of different pollutants from soil and atmosphere. For this reason, in recent years the Yerevan Municipality (Abstract from RA, 2014; www.yerevan.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 (CENS) NAS RA (Publ.: Center for Ecological-Noosphere Studies NAS RA, 2007-2008). Based on the obtained geochemical, ArcGIS information system 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 mentioning 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 and through creation of a target greening net (Book of statistical data, 2009-2011; Danielyan, 2008; Publ.: Center for Ecological-Noosphere Studies NAS RA, 2007-2008; Mkhitaryan, 2014). 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.

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. 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 the 1st 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 (Abstract from Yerevan, 2014; Oleynik, E., 1999).

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. 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.

References

A strategic program of prospective development of the Republic of Armenia 2014-2015. (2014). Abstract from RA Government decision N 442 -N as of March 27 -2014, Yerevan. 165-171.

By the number of marzes of the Republic of Armenia. (2009-2011). Book of statistical data, 141-150.

Danielyan, K., Sargsyan, L., Sargsyan, T. (2008). Analysis of environmental status. Publ.: Lusakn. Yerevan, 39 p.

Developing a target greening program for Yerevan, studying heavy metal pollution of soils and developing a map. (2007-2008). Publ.: Center for Ecological-Noosphere Studies NAS RA. Yerevan, 105 p.

Hovhannisyan, H.A., Nersisyan, G.S., Khachatryan, L.R. (2015). Greening as one of efficient urban environment pollution management methods for city of Yerevan, Armenia. Book of proc. of Biotechniques Ghent Congress 2015 - the 6th international conference on Biotechniques for air pollution control, Ghent, Belgium, 2-4 September, 377-384.

Mkhitaryan, R., Petrosyan, G. (2014). A methodic manual for state monitoring of public green spaces and their management processes (European endowment for democracy). Gyumri. 116 p., 122-125.

Vasilenko, V.A. (1995). Economy and ecology: problems and searches for sustainable development ways. Novosibirsk. 1-6.

Yerevan Development Program for 2013-2015. (2014). Abstract from Yerevan Mayor's decision 263-N as of December 23. Yerevan.

Oleynik, E.M. (1999). Harmonization of economic and ecological development. Moscow, 5 p.

www.ncsd.am

www.yerevan.am

How to Show Water at the Micro-World Level?

Małgorzata Nodzyńska

Pedagogical University of Cracow, Institute of Biology, Didactics of Natural Sciences Research Group, Podchorążych 2, 30-084 Kraków, malgorzata.nodzynska@gmail.com

In Poland majority of students dislike studying chemistry. It appears as if the main reason for this is that students consider chemistry a difficult subject to study.

Students find it very difficult to make connections between what they observe in the world around them (macroscopic properties) and the sub-microscopic world of particles, atoms and subatomic units. Yet in order to make sense of the macroscopic properties, chemists switch to the sub-microscopic scale where they use explanatory models to try and explain their observations (Nodzyńska 2012).

When it comes to chemistry education it is important that the usage of models (and connected to them theoretical concepts) on subsequent stages of education complements and expands upon the models adapted on preceding levels. However, in Polish Education that does not happen. On each stage of education the chemical models that are used are changed (Fig 1.).

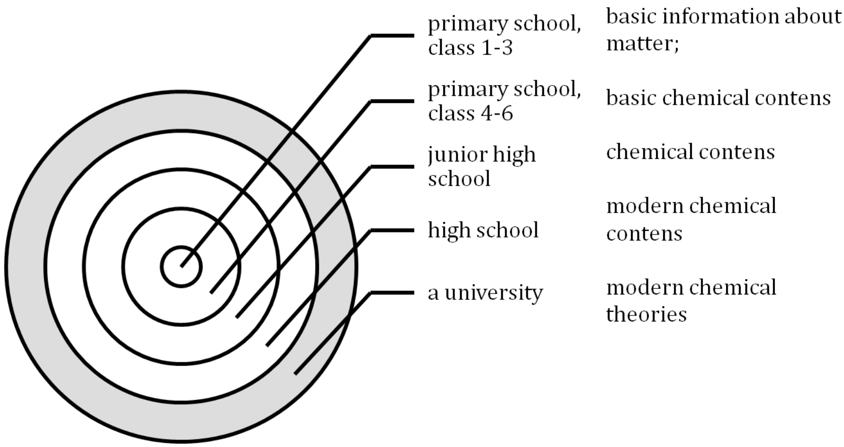


Figure 1. Chemical knowledge to the next levels of education (theory)

Figure 2 shows how on consecutive stages of education we change the theory of chemical and thus used model.

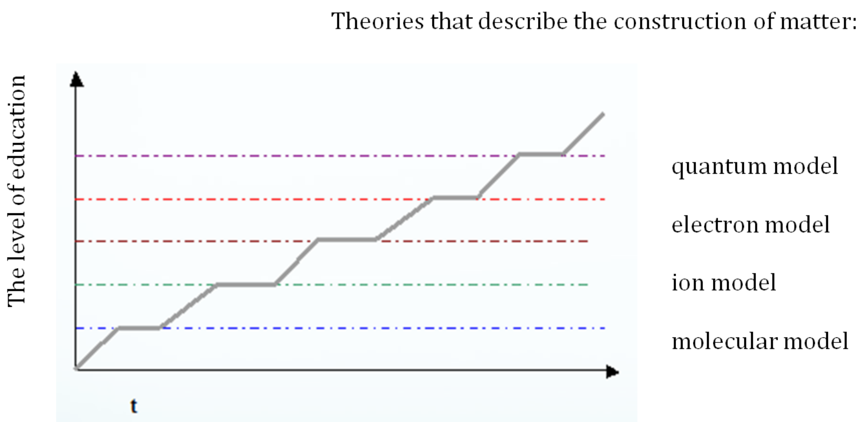


Figure 2. Chemical knowledge to the next levels of education (practice)

Here we show this inconsistency on the example of water molecules:

– From 4^{th} to 6^{th} (from ages 10 to 12) grade in primary education during the sciencie classes the water molecule is presented as solid ball

– In junior high school the students are shown two different models depending on the subject (whether it is chemistry or physics class)

  – during the physics course they treat water molecule as dipol (an eloganted, ovoid molecule with clear distribution of positive and negative charge)

  – during chemistry classes in 1^{st} grade of junior high school students learn about angular formation of the water molecule and in 3^{rd} grade they're presented with inner structure of the particle with electrons and chemical bonds made by those electrons underlined (this is so called simplified electrons "dot" model)

– In High school (ages from 17 to 19) students find out about hydrogen bonds between water molecules

– In college and universities they're introduced to quantum structure of molecules and donor-acceptor bonds (Nodzyńska 2012).

So students during their school education encounter many different models. For gifted pupils or older students such diversity of models is a positive factor. It shows them that different models represent different properties of matter. But in the case of: younger pupils or students who are unable to break away from the material models, so much diversity leads to a surge of information and to chaos.

It may be worth to contemplate whether we really need to show to students such precise depiction of water molecule during their elementary education.

Yet, we need a correct model of a molecule of water to explain:

- The shape of Snowflakes
- Surface tension of water
- Solubility of substance in water

It seems that when it comes to non-scientific profiles we could use one, simplified model during courses throughout subsequent stages of education (primary, junior high school, high school). On the other hand the more precise models should be applied in high school and university education of science-oriented groups and classes. Perhaps usage of just one, simplified model in education would make the learning process more friendly and accessible (and as a result – much more enjoyable) to those students that are not interested in pursuing science-oriented careers.

Hopefully, such approach would also change the general attitude of students towards chemistry to much more positive.

References

Nodzyńska, M. (2012) *Wizualizacja w chemii i nauczaniu chemii*, Wydawnictwo UP, Kraków: Poland.

The Spirit of Chemistry in a School Textbook

Małgorzata Nodzyńska, Paweł Cieśla

Pedagogical University of Cracow, Institute of Biology, Didactics of Natural Sciences Research Group, Podchorążych 2, 30-084 Kraków, pawel.ciesla.33@gmail.com, malgorzata.nodzynska@gmail.com

In Poland, according to the core curriculum of teaching natural sciences compulsory chemical teaching takes place in gimnazjum (third educational level) and with limited number of hours in first class of the high school. Chemistry in the second and third classes of high school is reserved for those who have chosen course of advanced chemistry. However, many pupils ends their chemical education at the basic level. It often happens, that those pupils launch their graduate studies at some non-chemical branches at which the knowledge of chemistry in basic level is necessary i.e. biology, pharmacy, environmental protection, technical studies etc. It is why the chemical knowledge that pupils gain at gimnazjum is of crucial importance. Based on these important fact the idea of designing innovatory textbook (Nodzyńska & Cieśla, 2015a, 2015b, 2015c) arose. The textbook comprises many years of authors' practicing as academic teachers, gimnazjum teachers as well as results of scientific research on teaching and learning new concepts and chemical theories.

The main assumptions of the textbook are:

– Chemistry is shown in positive light against to stereotypes. It is realised through references to the everyday life, belles-lettres and correlation with other subjects.

– It is very difficult to answer some questions without introducing more complex scientific theories, however lack of explanation makes learning chemistry by heart. The textbook helps understanding chemistry. It is realised through thorough explanations of every content the pupils should know at this level of education (according to the core curriculum). Sometimes it required the extension of these contents and introducing the additional ones. Moreover in chemistry there is a specific dualism observed. The experiments are done in macroworld, however their explanation should be searched in micro-world. Basing on this assumption the mission of the textbook is to reveal and to emphasize this dualism.

– The textbook resigns from traditional linear, concentric and spiral arrangement of teaching content (Kupisiewicz, 1995). Instead of that authors introduced looping one which can be compared to crocheting. It needs to remember that a lot of skills the pupils should have mastered at the end of this stage of education and not as many teachers think to the next lesson. Thus these skills should be practiced in all period of the educational process and regularly monitored however pupils should have enough time to gain that skills. In order to enable to practice them information is repeated several times and used in various contexts. Every notions which are introduced are used in further lessons and thank to that even the pupils with learning difficulties can learn such notions. Moreover, each of 15 chapters ends with a cross-sectional summary. The final 16th chapter is cross-sectional as well.

– There is no division to organic and inorganic chemistry. In Poland it can be noticed only in a few textbooks (Paśko, 1999, 2000; Paśko & Nodzyńska 2009 i 2010), however at this stage of education chemistry should be treated in a holistic way. There is a lot of inorganic and organic compounds that have similar properties and take part in chemical reactions very similarly. Thus there is no need to introduce such a division. Moreover, it allows to save the time which is always short at school.

– There is no chemistry without chemical experiments. The role of experiments in learning chemistry was discussed several times (Bilek, 1999; Nodzyńska et al., 2014) and there is no need to convince anyone how important the experiments are in learning procedures of scientific research and in developing pupils' critical thinking. The textbook comprises proposition of 285 various laboratory experiments which enables pupils to check the properties of chemical substances, discover how they react with other chemicals and finally to formulate hypotheses, verify them and make conclusions based on observed results of experiments. Developing critical and logical thinking is also supported by a lot of mental experiments that aim in resolving scientific problems and concluding basing on deduction and induction.

The content of the textbook

As it was mentioned above the content of the textbook is divided into 16 chapters. Research show that in learning chemistry the structure of the concepts formed in the student's mind strongly depends on the structure of concepts presented to the student in the educational process (Regis at all, 1996). Thus, in the textbook a special attention was paid to the structuring of teaching content. The key concepts were extracted and highlighted. To be in accordance to achievements of glottodidactics the authors tried to avoid introducing more than 7 notions in one lesson, moreover the notions were introduced in a specific order.

The learning process starts with the introduction of the atomic structure in terms of quantum mechanics in the way which was previously reported (Cieśla, 2012, 2014). This is the first textbook for gymnasium (pupils 13-16 years old) which introduces quantum numbers, orbitals and graphical representation of electron configuration based on s, p, d, f orbitals. The first chapter also introduces other micro-world chemical species which are of crucial importance i.e. ions and molecules. In the second chapter the concept of mole is introduced. It is used, especially for the purposes of correct naming ionic compounds and for chemical calculations as well. The next chapters explain properties of most important gases, metals and nonmetals. After that, the properties of simple compounds with hydrogen are discussed.

Introducing of orbitals at the beginning of learning enabled to briefly describe the term hybridisation. Base on that the shapes of molecules of hydrocarbons were discussed. Moreover, a lot of time was devoted for isomerism, nomenclature of various structures of hydrocarbons as well as typical chemical reactions of saturated and unsaturated hydrocarbons and their derivatives.

Next few chapters were intended to properties of oxides, water solutions, acids, bases, hydroxides, alcohols, salts and finally organic substances known from everyday life. The final chapter is cross sectional and chemistry is shown there in a holistic way.

Conclusions

The textbook allows pupils to effectively learn chemistry and practice it basing on understanding chemical processes as well as the behaviour of specific groups of chemicals. It transforms the scientific knowledge into the school knowledge and it makes the school chemical knowledge up to date. It also emphasizes the role of chemistry in various aspects of everyday life.

References

Bilek, M. (1999). Počitačem podporovany chemicky experiment i na zakladni škole. *Biologie, chemie, zeměpis*, 8 (3), pp. 140 – 145.

Cieśla, P. (2012). Jak uczyć o strukturze atomu w gimnazjum, bazując na podstawach mechaniki kwantowej. In P. Cieśla, M. Nodzyńska & I. Stawoska (Eds.), *Badania w dydaktyce chemii* (pp.15–20). Kraków, Pedagogical University of Kraków.

Cieśla, P. (2014). Structure of Matter at Secondary School – Results of the Research. In M. Bílek (Ed.) *Research, Theory And Practice In Chemistry Didactics. Proceedings of the 23rd International Conference on Chemistry Education Hradec Králové* (pp.157–164). Hradec Králové, Gaudeamus.

Kupisiewicz, Cz. (1995) *Podstawy dydaktyki ogólnej* (p. 70), Warszawa, Poland: Polska Oficyna Wydawnicza "BGW".

Nodzyńska et al. (2014). *Experiments in teaching and learning natural sciences*. M. Nodzyńska, P. Cieśla, & A. Kania, (Eds.). Kraków, Poland: Pedagogical University of Cracow.

Nodzyńska M., & Cieśla P. (2015a). *Duch chemii część 1. Gimnazjum*. Lublin, Poland: Syntea S.A.

Nodzyńska M., & Cieśla P. (2015b). *Duch chemii część 2. Gimnazjum.* Lublin, Poland: Syntea S.A.

Nodzyńska M., & Cieśla P. (2015c). *Duch chemii część 3. Gimnazjum*. Lublin, Poland: Syntea S.A.

Paśko, J. R. (1999). *Chemia dla klasy I gimnazjum*, Krzeszowice, Poland: Kubajak.

Paśko, J. R. (2000). *Chemia część II dla gimnazjum*, Krzeszowice, Poland: Kubajak.

Paśko, J. R., & Nodzyńska, M. (2009) *Moja Chemia dla gimnazjum część 1*, Krzeszowice, Poland: Kubajak.

Paśko, J. R., & Nodzyńska, M. (2010) *Moja Chemia dla gimnazjum część I1,* Krzeszowice, Poland: Kubajak.

Controversial Socio-Scientific Issues in Chemistry Teachers' Education

Ján Reguli

Department of Chemistry, Faculty of Education, Trnava University, Trnava, Slovakia, jan.reguli@truni.sk

In recent years we perceive several problems concerning low level of education and at the same time disappointment of people with the function and service of democratic institutions. These problems result in the trust of young people in various conspiracy theories. Some extreme political groups succeeded in addressing the young people.

We face decreasing level of scientific literacy of Slovak pupils (assessed by PISA). It is related with their poor communication and decision making skills.

There are several reasons, why chemistry and other school subjects are not able to attract pupils' interest and why these subjects do not prepare young people to real life, where they are asked to apply their knowledge and to make decisions in real, often unexpected and controversial circumstances.

One among these reasons may consist in the contents of school chemistry. Pupils do not see any connection between chemistry and real life, which they live in. They do not meet the chemical elements and compounds that form the contents of school chemistry. Neither are they confronted with any of the taught types of chemical reactions. To overcome this gap between school chemistry and real life, many countries have introduced "conceptual chemistry" or "chemistry in context" with real life.

Further possible approach consists in involvement of controversial socio-scientific issues, drawn from real life situations, into school education. Discussing these issues pupils can lead to their deeper understanding. Also they can develop critical thinking and gain communication skills.

Chemistry teachers need to be prepared to discuss these issues with students. Therefore controversial socio-scientific issues have to be involved in undergraduate chemistry teachers' education.

What are controversial issues?

Controversial issues are those issues, which people feel important to them and to society and which divide people's opinions within society because people strongly disagree about statements, assertions, and actions to be taken. Groups of people within society may hold different values, promote conflicting or opposing viewpoints, and offer alternate interpretations and explanations for events to suit their position (*Teaching Controversial Issues at Key Stage 3.*).

What can make an issue controversial?

An issue might be controversial because there is not enough information or evidence available for an informed debate about it. Issues are also likely to be controversial, when people believe that they are part of an agenda serving political, religious or economic interests. Schools and all subject teachers need to be prepared to discuss these issues with students.

What are the general controversial issues?

Examples of controversial issues include abortion, drug legislation, alcohol drinking age, drugs in sport, child labor, sexual orientation and same sex marriage, death penalty, immigration and asylum seekers, assisted suicide (euthanasia), animal rights and animal testing, and others.

What are the controversial socio-scientific issues?

Many controversial issues deal with science or chemistry. These issues involve genetically modified organisms and genetic engineering in general, deforestation, global warming, stem cell research, hydraulic fracturing for shale gas, and others.

Why teach controversial socio-scientific issues?

Pupils can develop a deeper understanding about important issues. They learn to handle disagreement and acknowledge other viewpoints, learn to work collaboratively, develop their communication skills, as well as learn to respect the views of others. They develop higher order thinking skills and learn how to become critically reflective thinkers.

Teachers may avoid teaching controversial issues for a variety of reasons including lack of confidence. However, teaching controversial and sensitive issues can be challenging, because they may be based on or lead to conflicting values and arouse strong feelings in pupils. Pupils can gain a deeper understanding of such issues. They can develop critical thinking and communication skills. Learning about controversial issues helps prepare pupils for civic and political participation.

Controversial SSI in chemistry teachers' education at Trnava University

Controversial SSIs are applied in two subjects of chemistry teachers' education at Trnava University – *Science Communication* and *Consumer Chemistry*. These subjects try to improve those competencies of teachers which seem to be very important nowadays: Communicating skills, ability to explain phenomena, processes, and materials that pupils meet in everyday life, and decision making skills (Reguli, 2015).

Examples of controversial SSI linked with science or chemistry

Hydraulic fracturing (fracking) – a new method of mining natural gas and oil from the shale rocks (especially developed in the USA) – provides a chance to have a cheaper source of gas, but it may lead to serious pollution of ground water, sometimes even to earthquakes. Many fracturing fluid chemicals are known to be toxic to humans and wildlife.

Genetically modified organisms were involved in agriculture to enhance the crop production and lessen the amount of the herbicides needed. People, especially in Europe, consider dangerous and unacceptable almost all methods and results of genetic engineering, including GMO – though new studies have found no threats concerning consummation of GM food.

Effect of people to climate change. Global warming is connected with the greenhouse effect. We have to lower the amount of greenhouse gases (CH_4, CO_2) in our atmosphere. Yet, there are still some politicians who do not believe in the global warming of our atmosphere. They are not ready to accept expensive actions to lower the CO_2 content in the atmosphere.

There are many myths and misconceptions connected with climate warming and impact of people. People mix greenhouse effect with ozone hole, or ozone hole with ozone pollution in towns due to heavy traffic.

Stem cells have the potential to develop into many different cell types in the body during early life and growth. Until recently, scientists primarily worked with two kinds of stem cells: embryonic stem cells and non-embryonic "somatic" or "adult" stem cells. Many people consider using of embryonic stem cells not acceptable from ethical reasons.

Vaccination works by stimulating the immune system, the natural disease-fighting system of the body. Opposition against vaccination may result in low level of immunization in the population and in return of infectious diseases that we have for long forgotten. No serious research studies have found any causality between vaccination and various problems of some of the vaccinated children.

Homeopathic remedies and alternative medicine. All meta-analytical studies show that the effect of homeopathic remedies and effect of a placebo are the same. Some people, facing serious diseases, trust various alternative "medicine-men" instead of regular physicians and treatment with officially approved drugs. Conspiracy theories speak about pharmaceutical lobby that doesn't allow using cheaper “alternative remedies”… Many people die due to late proper treatment by a professional physician.

Conclusions

Science teachers are often facing students’ controversial questions on issues that are related to conspiracy theories or theories which are scientifically unacceptable. Teachers have to be prepared to discuss with students also such topics. Academic debates provide an attractive approach to involvement of controversial socio-scientific issues at chemistry lessons.

Acknowledgements

This contribution is supported by Ministry of Education of the Slovak Republic through the project KEGA 003TTU-4/2016 *Chemistry and Society*.

References

Teaching Controversial Issues at Key Stage 3. (Northern Ireland Curriculum) Available at http://ccea.org.uk/sites/default/files/docs/curriculum/area_of_learning/CCEA_Controversial_Issues.pdf

Reguli, J. (2015) Equilibrium between chemical knowledge and teaching skills in pre service teachers’ education. *6th Eurovariety in Chemistry Education : Chemistry Education for Responsible Citizenship and Employability.* Tartu 30. 6. – 1. 7. pp. 46 – 47. ISBN 978-9949-9654-2-7.

The Most Common Misconceptions of Primary School Students Associated with Oxygen

Monika Šindelková

Introduction

The teacher should work with the general misconceptions of students during the learning process. Wenning (2008) shows the problems arising from imperfectly designed teaching methods, teaching forms, activation methods and experiments during the educational process. He views certain alternative concepts as correct or incorrect conceptions that have been acquired under specific conditions.

Diagnostic methods for misconception

In order to diagnose a student's misconception of specific terms or ideas concept maps, interviews, analysis of students' drawings or three-tier tests is frequently used. Gurel, Eryilmaz & McDermott (2015) performed a study on the current research tools used to identify a student's misconceptions. Their study provides short description of each tool studied and provides a comparison of the advantages and disadvantages of using different diagnostic methods from 1980 until 2014.

Three-tier test

The three-tier test is a new research method that offers arguments and explanations of the selection. It is comprised as three parts that allow students to express their certainty or uncertainty of the concept or idea being tested through their answers. Therefore this test is able to distinguish misconception from lack of knowledge. Three-tier tests are very effective for use when testing a large and statistically significant sample of respondents (Kirbulut, 2014). A few statistical methods are used for the evaluation of three-tier tests. The authors Pesman (2010), Arslan, Cigdemoglu & Moseley (2012), Cetin-Dindar (2011) and Caleon (2010) use the Cronbach alpha coefficient and the Pearson correlation coefficient to evaluate three-tier tests.

Methods and results

The main goal of this pilot research is to diagnose the most common misconceptions associated with the term "oxygen" held by 8th grade students of primary school. The number of respondents for the research was 120 (the 8th grade students of primary schools in the region of the Czech Republic). Time for filling the test was 15 minutes. The respondents' answers were divided in several categories. The respondents' answers were subjected to statistical evaluation. Pesman (2010) argues that correlations should be slightly positive. The obtained value 0.69 is statistically significant at a significance level of $p < 0.01$.

The results of the pilot research show that the 8th grade students from the selected primary schools know the term "oxygen" and they identify it as a gas substance. They can choose the most common two element compounds of oxygen. Respondents cannot distinguish between the density of oxygen and air; no respondent has scientifically correct ideas about the difference in the density of oxygen and the density of air. Respondents do not know the triatomic molecule of oxygen (ozone). More than 25 % of the students argue that the triatomic molecule is oxide. Another complicated question for respondents dealt with aerobic and anaerobic organisms and their need for oxygen in metabolic processes. Only 31 % of respondents indicated that aerobic organisms need oxygen for their metabolic processes.

References

Arslan, H., Cigdemoglu, C., & Moseley, C., (2012). A Three-Tier Diagnostic Test to Assess Pre-Service Teachers' Misconceptions about Global Warming, Greenhouse Effect, Ozone Layer Depletion, and Acid Rain. International Journal of Science Education [online]. 34(11), 1667-1686 [cit. 2016-02-02]. DOI: 10.1080/09500693.2012.680618. ISSN 09500693. http://www.tandfonline.com/doi/abs/10.1080/09500693.2012.680618.

Caleon, I. (2010). Development and application of a three-tier diagnostic test to assess secondary students' understanding of waves. International Journal of Science Education [online]. 32(7), 939 - 961 [cit. 2016-02-01]. DOI: 10.1080/09500690902890130. ISSN 09500693. http://www.tandfonline.com/doi/abs/10.1080/09500690902890130#.Vz174NSLTwc

Cetin-Dindar, A. (2011). Development of a three-tier test to assess high school students' understanding of acids and bases. Procedia - Social and Behavioral Sciences [online]. 15, 600-604 [cit. 2016-02-01]. DOI: 10.1016/j.sbspro.2011.03.147. ISSN 18770428. http://www.sciencedirect.com/science/article/pii/ S1877042811003260.

Gurel, D., Eryılmaz, A., & McDermott, L., (2015). A Review and Comparison of Diagnostic Instruments to Identify Students' Misconceptions in Science. EURASIA Journal of Mathematics, Science [online]. 11(5), 989-1008 [cit. 2016-02-02]. http://www.ejmste.com/ms.aspx?kimlik=10.12973/eurasia.2015.1369a&nerden=2.

Kirbulut, Z. (2014). Using Three-Tier Diagnostic Test to Assess Students' Misconceptions of States of Matter. EURASIA Journal of Mathematics, Science [online]. 10(5), 509-521 [cit. 2016-02-02]. http://www.ejmste.com/

ms.aspx?kimlik=10.12973/eurasia.2014.1128a.

Peşman, H. (2010). Development of a Three-Tier Test to Assess Misconceptions About Simple Electric Circuits. Journal of Educational Research [online]. 103(3), 208- 222 [cit. 2016-02-02]. ISSN 00220671. http://www.tandfonline.com/doi/abs/10.1080/00220670903383002.

Wenning, C. (2008). Dealing more effectively with alternative conceptions in science. In Journal of Physics Teacher Education [online]. 5(1) [cit. 2016-01-25] ISSN 1559-3053. http://www2.phy.ilstu.edu/pte/publications/dealing_alt_con.pdf.

Comprehending Newly Designed Activities for Computer Based Science Lab by Slovak and Czech Students

Marek Skoršepa, Petr Šmejkal

Slovakia, Czech Republic
marek.skorsepa@umb.sk, psmejkal@natur.cuni.cz

Introduction

Computer aided experiments represent a popular way of experimenting in science education. Moreover, this kind of experimenting was confirmed beneficial for the process of learning by many prominent authors and their studies (Aksela, 2005, Lavonen et al. 2003).

Our contribution deals with an implementation of a set of 18 newly designed research-based computer supported laboratory activities for Chemistry (12 activities) and Biology (6 activities), which were proposed by an international team of researchers from 5 European countries: Spain, Czech Republic, Austria, Finland and Slovakia (Tortosa et al., 2013). More specifically, the partial results from Czech and Slovak part of the research is presented. The main aim of the study is to answer the questions related to understanding the objectives of proposed and implemented activities by the secondary school students. All activities have the uniform structure inspired by the previous study (Tortosa, 2012). They are designed to be student-centered reflecting the IBSE principles and POE sequence (Predict – Observe – Explain) suggested by White & Gunstone (1992).

Methods

During the process of implementation with secondary school students (mean age 16.97; SD 1.20) 1408 evaluations were performed with 664 students from 15 participating schools (11 in 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) because of the lack of necessary equipment in the schools.

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: (Item 1) *I understood the objectives of the activity*; (Item 2) *List the objectives of the activity*; (Item 3) *I need my teacher's help to understand the activity*; (Item 4) *Computer measuring system helped me interpret the results* and (Item 5) *I think the activity could* *be done without computer measuring system*. Items number 1, 3, 4 and 5 are positive declarative clauses where students expressed their level of agreement on 4-point Likert scale (1 = I totally agree, 2 = I agree, 3 = I disagree, 4 = I totally disagree). In open item number 2 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. Data were processed by several statistical methods, such as descriptive statistics, analysis of frequencies and comparative analysis (gender, subject, country, age, place of implementation). The significance was determined by non-parametric Mann-Whitney U test or Kruskal-Wallis H test at 0.05 level.

Results

Analysis of frequencies revealed that the most students (94.7%) think that they understand the objectives of implemented activity (cumulative percent for all answers of agreement with the declarative clause has been taken into account). However, when they were asked to list the objectives, only 58.1% of correct (scale point 1) or more or less correct (scale point 2) answers were provided. As these results didn't distinguish between the activities we also compared them and identified the most difficult ones to be revised. Comparisons based on different place of implementation showed that students performing in university not only felt more competent but also reported more correct answers than students working in the schools (ITEM 1: U = 251 102.000; z = 6.356; $\boldsymbol{p} = \mathbf{.000}$; MR_{school} = 757.25, $MR_{university}$ = 643.06; ITEM 2: U = 251 102.000; z = 6.356; $\boldsymbol{p} = \mathbf{.000}$; MR_{school} = 726.75, $MR_{university}$ = 596.35). About 45% of the students declared the need of their teacher's help in understanding the activity objectives. Interestingly, students performing in university reported significantly less frequent need of the teacher's help then students implementing in the schools (U = 178 029.000; z = –5.486; $\boldsymbol{p} = \mathbf{.000}$; MR_{School} = 612.51; $MR_{University}$ = 730.13). In ITEM 4 the most students reported that computer measuring system helped them interpret the results. Moreover, students working in universities considered computer measuring system helpful more often than students in the schools (U = 250 486.000; z = 5.916; $\boldsymbol{p} = \mathbf{.000}$; MR_{School} = 765,95; $MR_{University}$ = 647,80). Surprisingly, when we asked students if they think the activity they are just performing could be also realized without computer measuring system, more than one third of them (35.4%) reported positive answers.

Conclusions

The actual study uncovered that most students tend to perceive their level of understanding the activity more overrated then reality. This fact is one of the important one to help us refine the activities. Furthermore, the study also showed an interesting impact of place of implementation 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. The level of help of computer measuring system in interpreting the results was declared more notably by the students working in university as well. We can presume that new and serious environment like university and its laboratory could influence students in their behaviour and make them more engaged and active for learning. It is promising that almost all students considered computer measuring system helpful in solving the experimental problem they were working on. A bit surprising is 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 computer based experimenting. Namely, it was the first experience with computer measuring system for the most 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

Support by grants KEGA No. 029UMB-4/2014 and EACEA No. 517587-LLP-1-2011-1-ES-COMENIUS-CMP is acknowledged.

References

Aksela, M. (2005). *Supporting meaningful chemistry learning and Higher-order thinking through computer-assisted inquiry.* Academic Dissertation. University of Helsinki.

Lavonen, J., Aksela, M., Juuti, K. et al. (2003). Designing user-friendly datalogging for chemical education through FA of teacher evaluations. *Int. J. Sci. Ed.*, 25(12), 1471–1487.

Tortosa, M. (2012). The use of MBL in chemistry second. education: Present state of the art and ideas for research-based practice. *Perspective. Chem. Educ. Res. Pract. 13*, 161–171.

Tortosa, M., Guitart Mas, J., Skoršepa, M. et al. (2013). Los objetivos de actividades de laboratorio diseñadas para la adquisición de competencia científica mediante experimentos en tiempo real: visión del alumnado. *Enseñanza de las ciencias*, (num. extra), 3547-3553. ISSN 0212-4521.

White, R. & Gunstone, R. (1992). *Probing understanding.* London. The Falmer Press.

Self-Reported Czech and Slovak Students' Feedback on Performing Activities in Computer Based Science Lab

Petr Šmejkal[1], Marek Skoršepa[2], Eva Stratilová Urválková[1]

[1]Department of Teaching and Didactics of Chemistry, Faculty of Science, Charles University in Prague, Prague, Czech Republic
[2]Department of Chemistry, Faculty of Natural Sciences, Matej Bel University, Banská Bystrica, Slovakia
psmejkal@natur.cuni.cz, marek.skorsepa@umb.sk, urvalkov@natur.cuni.cz

Introduction

Microcomputer based laboratory (MBL), also called Probeware, is a prospective tool for more efficient and more interesting teaching of variety of themes attributed to all science branches and well reflects the increasing ratio of employment of instrumental devices and various probes in lab practice and in common life. In fact, the MBL (Probeware) is a set of various sensors which can be connected to and controlled by various kinds of computer systems (datalogger, PC, smart device, calculator etc.). For the particular MBL system, a common way of connection of individual parts of the system and control of the system is characteristic. In addition to that, the parts of the system are designed with respect to school application, which means user-friendly software, small and robust construction etc. Benefits of MBL were discussed by many authors (Lavonen et al, 2003, Hamne & Bernhard, 2001, Thornton & Sokoloff, 1990, Tinker, 1996), for example, the enhancement of scientific competencies and development of abstract thinking were proved. Although implementation of MBL can bring a variety of advantages and well demonstrate some aspects and themes of the science branches over the experiment made "traditionally", there are still obstacles which hinder the implementation into Czech and Slovak schools. One of them is a lack of well-designed research based MBL materials (lab worksheets, technical sheets, etc.) and a lack of technical support to teachers implementing the MBL systems into their school practice. There is also a question whether attitudes of students to MBL and sensors are positive or they are oversaturated by computer systems or whether the work with MBL is too complicated. With respect to the mentioned obstacles, in the framework of European project COMBLAB, a new set of inquiry based laboratory activities has been developed and implemented in laboratory courses for secondary school students. The concept of the activities and the activities were already presented during DidSci 2012 conference by Stratilová Urvalková et al. (2012) and they are available at www.comblab.eu. This contribution deals with self-reported Czech and Slovak students' feedback on performing activities in computer based science (MBL) lab and compare the attitudes and opinions of Czech and Slovak students on work with MBL systems and the presented activities.

Methods

The attitudes and opinions of the students participating the courses were collected through newly designed 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). For this study, seven following questionnaire items were selected to be discussed in more detail: (Item 1) *I found the activity interesting and motivating*; (Item 2) *The instructions were clear to me*; (Item 3) *Overall, how satisfied were you with the activity*; (Item 4) *It was easy to set up the experimental equipment*, (Item 5) *It was easy to work with the computer system*; (Item 6) *I needed my Teacher's help to perform the experiment* and (Item 7) *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.

Results

The results showed that majority of the students considered the activities to be interesting and motivating (> 93 %) with clear instructions (> 88 %). More than 88 % stated that work with the MBL system and a set-up of the system was simple, on the other hand, more than 50 % of participating students needed some help of teacher. More than 90 % of students also consider MBL beneficial for their personal knowledge development and over 70 % mentioned that knowledge from the lab course is well applicable in other science courses. This statement was typical independently on the fact whether the MBL system was implemented for the first time or more times. Nevertheless, the significant differences between Czech and Slovak students were identified. Slovak students showed more positive attitudes to activities (ITEM 1: U = 155 207.000; z = -9.569; $\boldsymbol{p = .000}$;

MR_{CZE} = 757.50, MR_{SVK} = 564.57; ITEM 2: U = 136 844.000; z = -12.386; ***p* = .000**; MR_{CZE} = 777.79, MR_{SVK} = 525.99; ITEM 3: U = 110 398.000; z = -14.757; ***p* = .000**; MR_{CZE} = 772.92, MR_{SVK} = 470.43) and to work with MBL system (ITEM 4: U = 150 359.000; z = -10.126; ***p* = .000**; MR_{CZE} = 760.12, MR_{SVK} = 554.38; ITEM 5: U = 149 312.000; z = -10.562; ***p* = .000**; MR_{CZE} = 762.65, MR_{SVK} = 552.18). The Slovak students also reported less need of help from teacher (ITEM 6: U = 284 984.000; z = 10.531; ***p* = .000**; MR_{CZE} = 612.40, MR_{SVK} = 837.21) and they more support wider implementation of MBL into schools (ITEM 7: U = 165 585.000; z = -8.683; ***p* = .000**; MR_{CZE} = 700.11, MR_{SVK} = 586.37. On the other hand, in overall, the results show that students of both countries positively evaluated the activities as well as work with MBL systems and designed activities and consider their implementation in science courses as meaningful and useful.

Conclusions

The developed and tested activities were evaluated in overall very positively as interesting and motivating; comparing two countries: the activities were evaluated more positively by Slovak students than by Czech students. The Slovak students also considered the setup as well as work with MBL system as easier and they also reported less need of help from teacher than the Czech students. In addition to that, Slovak students would appreciate more frequent use of MBL in lab classes and in overall, they showed higher motivation and more positive attitude than the Czech students. As a consequence, the implementation of MBL and the activities in the Czech Republic could be more complicated for Czech teachers. On the other hand, attitudes of the Czech students are still very positive and majority of students support implementation of MBL and performed activities are considered to be of high quality by both, Czech and Slovak students.

Acknowledgements

We thank students and teachers who participated in the implementation and evaluation of the proposed activities. The work has been supported by EACEA grant No. 517587-LLP-1-2011-1-ES-COMENIUS-CMP and by project PRVOUK P42.

References

Hamne, P. & Bernhard, J. (2001). Educating pre-service teachers using hands-on and microcomputer based labs as tools for concept substitution. In R. Pinto, & S. Surinach (Eds.) *Physics Teacher Education Beyond* 2000 (663-666). Paris: Elsevier.

Lavonen, J., Aksela, M., Juuti, K. et al. (2003). Designing user-friendly datalogging for chemical education through FA of teacher evaluations. *Int. J. Sci. Ed.*, 25(12), 1471–1487.

Stratilová Urválková, E., Šmejkal, P., Skoršepa, M., Teplý, P., Tortosa Moreno, M. (2014). MBL activities using IBSE: learning biology in context. In *Experiments in teaching and learning natural sciences.* Krakow: Pedagogical University of Krakow, pp. 34-37.

Thornton, R. K. & Sokoloff, D. R. (1990). Learning motion concepts using real-time microcomputer-based laboratory tools. *American Journal of Physics*, 58(9), 858-867

Tinker, R. (1996). *Microcomputer-based labs: educational research and standards.* Berlin: Springer-Verlag.

Newly Designed MBL Activities Perceived by Slovak and Czech Secondary School Teachers (A Comparative Study)

Petr Šmejkal[1], Marek Skoršepa[2], Eva Stratilová Urválková[1]

[1]*Department of Teaching and Didactics of Chemistry, Faculty of Science, Charles University in Prague, Prague, Czech Republic*
[2]*Department of Chemistry, Faculty of Natural Sciences, Matej Bel University, Banská Bystrica, Slovakia*
psmejkal@natur.cuni.cz, marek.skorsepa@umb.sk, urvalkov@natur.cuni.cz

Introduction

Implementation of the microcomputer based laboratory (MBL) seems to be beneficial for students as well as teachers to learn (or teach) some phenomena and themes of science education. Benefits of the technology has been discussed by many authors (e.g. Lavonen et al., 2003, Thornton & Sokoloff, 1990). For example, the enhancement of scientific competencies (Tinker, 1996) or development of abstract thinking (Hamne & Bernhard, 2001) were proved for pupils using MBL. MBL approach also well reflects current state when employment of various sensors in many applications in industry and in common life, e.g. in smart devices (Škopek, 2013), becomes very frequent. Despite its benefits, the implementation of MBL in the Czech Republic and Slovakia suffers from some problems, where price and availability of the sensors or MBL systems needn´t to be the most important. The acceptation of the technology by students as well as teachers is influenced by further factors, they can be 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 (Stratilová Urválková et al., 2014) and, the courses on MBL implementing the newly developed activities were held for Czech and Slovak teachers. Some teachers also implemented the activities directly in the schools. The developed activities and the structure of the courses are published and available at COMBLAB project webpage www.comblab.eu. In this contribution, we acquired and statistically treated opinions and attitudes of teachers on the created activities (on chemistry and biology) to get an appropriate feedback to the prepared activities and to identify the possible didactical and technical problems. We also compared opinions and attitudes of teachers from the Czech Republic and Slovakia.

Methods

To acquire and evaluate the opinions and attitudes of teachers, a special newly developed tool (39-item questionnaire) has been administered after performing each activity (implementation). 42 teachers participated in the questionnaire research (26 Czech and 16 Slovak), from 23 secondary schools (19 in the Czech Republic, 4 in Slovakia). Totally, 197 evaluations have been made (74 in the Czech Republic, 123 in Slovakia) and all teachers evaluated more than one activity (3-8). Totally, the teachers evaluated 16 different activities (10 activities focused on chemistry, 6 on biology). For this study, the following questionnaire items were selected to be discussed in more detail: (Item 1) *Overall, how satisfied are you with the activity as a teacher?*; (Item 2) *The difficulty of the activity is adequate to students' knowledge*; (Item 3) *The duration of the activity is optimal*; (Item 4) *The activity fits to our state educational curriculum*, (Item 5) *The objectives of the activity are well designed*. All the items are positive declarative clauses where teachers expressed their level of agreement on 4-point Likert scale – items 2 - 5 (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.

Results

The results indicate that, in overall, the teachers appreciate the activities and the application of MBL in the activities. They expressed some satisfaction with ca 98 % of activities evaluations, in more than 65 % evaluations, they were very satisfied (☺☺☺ ranking). Only 4 evaluations (of 197) showed dissatisfaction, nevertheless, there were no rankings in the most negative part of the scale (☹☹ or ☹☹☹). Majority of teachers also stated that the objectives of the activities are well designed (99 % of evaluations), the difficulty of the activity is adequate to students' knowledge (94 % eval.) and that the activity fits to their state educational curriculum (ca 93 % eval.). Also duration of the activities was considered to be absolutely optimal in ca 50 % of evaluations and appropriate in 41 % of evaluations. Despite different experience with MBL and possibilities and equipment at various schools, there were not principal differences between Czech and Slovak teachers (ITEM 1: U = 5 084.000; z = 1.632; ***p* = .103**; MR_{CZE} = 91.80, MR_{SVK} = 103.33; ITEM 2: U = 4 335.500; z = -.625; ***p* = .532**; MR_{CZE} = 101.91, MR_{SVK} = 97.25; ITEM 3: U = 4 996.500; z = 1.280; ***p* = .201**; MR_{CZE} = 92.98, MR_{SVK} = 102.62; ITEM 4: U = 4 821.500; z = 1.158; ***p* = .247**; MR_{CZE} = 92.53, MR_{SVK} = 101.20; ITEM 5: U = 4 949.000; z = 1.221; ***p* = .222**; MR_{CZE} = 93.62, MR_{SVK} = 102.24). On the other hand, there were statistically significant differences among the activities regarding difficulty

(ITEM 2: χ^2 = 39.700, ***p* = .001**), optimal time duration (ITEM 3: χ^2 = 29.584, ***p* = .030**), and suitability for the state educational curriculum (ITEM 4: χ^2 = 43.547, ***p* = .000**). On the basis of the results, the activities were sorted into three groups: Activities recommended for start with MBL which well fit the curriculum, have an optimal duration and have appropriate difficulty (Antacids, Acid Rains, Wine Titration, Germination, Blood Pressure, Fermentation, ECG), well evaluated but more difficult activities for experienced teachers and students (Photosynthesis, Greenhouse, Crap Metal, Fire Extinguisher) and time demanding, difficult activities (open IBSE) for advanced users of MBL and talented students (CO_2 in the Sea, Eutrophication). This classification should make the implementation of activities smoother.

Conclusions

The questionnaire research showed that all tested activities prepared in the framework of the COMBLAB project were evaluated very positively by the teachers and from their point of view, the activities are well applicable in their lessons. The objectives are defined adequately, instructions are clear and activities have logical structure. Difficulty, duration of the majority of the activities and contents (with respect to school curriculum) are appropriate, nevertheless, in some cases, there was statistically significant differences among the activities. Therefore, in some cases, some changes were made to make the activities shorter and less difficult. Czech and Slovak teachers evaluated the activities very similarly and the results showed no statistically significant difference between Czech and Slovak teachers in the case of all evaluated items of the questionnaire.

Acknowledgements

We thank teachers who participated in the implementation and evaluation of the proposed activities. The work has been supported by EACEA grant No. 517587-LLP-1-2011-1-ES-COMENIUS-CMP and by project PRVOUK P42.

References

Hamne, P. & Bernhard, J. (2001). Educating pre-service teachers using hands-on and microcomputer based labs as tools for concept substitution. In R. Pinto, & S. Surinach (Eds.) *Physics Teacher Education Beyond* 2000 (663-666). Paris: Elsevier.

Lavonen, J., Aksela, M., Juuti, K. et al. (2003). Designing user-friendly datalogging for chemical education through FA of teacher evaluations. *Int. J. Sci. Ed.*, 25(12), 1471–1487.

Stratilová Urválková, E., Šmejkal, P., Skoršepa, M., Teplý,P., Tortosa Moreno, M. (2014). MBL activities using IBSE: learning biology in context. In *Experiments* *in teaching and learning natural sciences.* Krakow: Pedagogical University of Krakow, Kraków, 2014, pp. 34-37.

Škopek, P. (2013). *Techbox: váš telefon je prošpikovaný sensory.* [Online], mobilnet.cz, 2004 - 2016 24net s.r.o., [cit. 21.8.2016]. Available at: https://mobilenet.cz/clanky/techbox-vas-telefon-je-prospikovany-senzory-12496

Thornton, R. K. & Sokoloff, D. R. (1990). Learning motion concepts using real-time microcomputer-based laboratory tools. *American Journal of Physics*, 58(9), 858-867

Tinker, R. (1996). *Microcomputer-based labs: educational research and standards*. Berlin: Springer-Verlag.

Science Summer Camps for Children - How We Do and How Should We Do?

Petr Šmejkal, Michaela Šmejkalová, Veronika Sutrová, Kateřina Freyerová, Zuzana Míková

Faculty of Science, Charles University in Prague, Albertov 6, 128 43 Prague 2, Czech Republic, psmejkal@natur.cuni.cz

Introduction

The science subjects, especially Chemistry and Physics, are not the favorite subjects among Czech pupils and repeatedly, they occupy the bottom levels of many subject rankings (Höfer & Svoboda, 2006, Picková, 2012). In addition to that, interest of pupils to study science subjects has been constantly decreasing in the Czech Republic recently. With respect to that, and due to principal importance of science subjects for society, support and advertisement of the science subjects are becoming necessary. As a consequence, many new activities promoting science and technical subjects have appeared. The activities are organized by broad spectrum of institutions as Ministry of Education, Youth and Sports of the Czech Republic, various youth organizations (DDMs – "Houses of Children and Youth", …), non-profit nongovernmental organizations (e.g. Tereza) etc. Many exceptional activities are organized by educational institutions, especially schools and universities providing secondary and tertiary education. The principal advantage of these institutions and their activities is that they can provide experts and appropriate technical and specialized support to ensure high professional quality of the activities. Faculty of Science, Charles University in Prague, as one of the front Czech science educational institutions, is also organizing many high quality promotional activities supporting the science education. Majority of these activities are targeted to secondary school teachers and students, nevertheless, there are also organized summer science camps which are devoted to primary school pupils, 9 – 15 years old. With respect to that, this contribution deals with organization and programme aspects of the summer camps held by Faculty of Science, Charles University in Prague to share information and experience with other people organizing (or planning to organize) science summer camps to enhance the quality of the science camps in general.

Organizational aspects of the summer camps and target group

The science camps are organized since 2012. The target group of children participating the science camps are the pupils of 9 – 15 years old with interest in science branches. The age range was determined on the basis of our experience with aim to provide homogenous scientific and leisure time programmes and activities for all the participants at appropriate level respecting children abilities (or with respect to their age). The science camp takes two weeks in summer and it is attended by up to 92 children.

Camp area

The camp is held in campground near village Běstvina in foothills of the Iron Hills in Eastern Bohemia (Pardubický kraj). The campground has been selected to fulfill few conditions: camp area is large enough (ca 40.000 m^2) and it is surrounded by a fence. It allows us to perform majority of activities inside the camp or in its vicinity to achieve high level of control and safety of children. The camp has a kitchen and possibility of supplies of electricity, water and internet, which is important for the scientific activities. It is also equipped with WCs units and showers with sewerage. We are allowed to use two log cabins as improvised chemistry and biology labs. The labs are relatively well equipped to ensure all the aspects of our scientific as well as leisure time activities and safety precautions. The labs can operate almost in the mode of "common" secondary school lab. In the campground vicinity, there are few ponds with possibility of swimming, they are also a source of samples for hydrobiology. The countryside is not very affected by heavy industry, so area is biologically very active with many living species and also with many biotopes. Moreover, the Iron Hills are well known for their interesting geology and geology discoveries, some of them are very typical for the territory.

Organizing team and staff

The organizing team consists of 24 all time staff members. One head, one economist, two medics (officially only one medic is necessary, nevertheless, in the case of more than 60 children, we recommend two medics), lectors and team leaders (17), two cooks and one cleaner. There are also two members of the staff ensuring non-scientific and leisure time activities. The selection of the members of organizing team is based on some criteria. The most important are previous experience of working with children and appropriate scientific background and knowledge. With respect to that, the members of the organizing team are mostly former and current students of all stages of university study (Ph.D., MSc., Bc.) and employees of Faculty of Science, Charles University in Prague. Everyone of the organizing team must attend medical training, training on occupational safety and health protection at work, training on "how to work with children" and training related to their role in scientific programme. All the trainings ensure high quality of the scientific as well as non-scientific parts of the science camps.

Programme and financial aspects

The programme of the summer science camps is focused on the subjects of science education taught at the organizing faculty. In particular, they are biology

(41 % of scientific activities), chemistry (25 %), geography and geology (17 %). Scientific activities are supplemented by thematic games and non-scientific activities. The programme is divided into independent scientific and non-scientific blocks, mostly 5 blocks are performed a day. The reason of the “block structure” of the programme is a possibility of changes according to changes in weather and other unpredictable situations (healthy problems of the lectors and team leaders, lack of samples in some time etc.). Scientific blocks are lectures, lab courses, excursions and projects, non-scientific blocks consist of games and leisure time activities. In the case of the scientific project, the children select at the beginning of the camp the particular project which corresponds the most to their orientation. In newly formed project teams, the children work during two weeks of the camp on the project and treat the results to present them at the end of the summer camp at the “scientific” conference.

The science camps are not financially supported by any project or donors, nevertheless, there is a support of dean of the faculty and support of educational departments of the faculty which provide some material and necessary equipment (glassware, microscopes, ICT etc.). The budget of the camps is filled mostly by parents of the participating children. The mentioned support of the faculty allows us to set the registration fee as low as EUR 215,-, which covers 5 meals a day (including 2-3 hot meals a day), all the educational materials, materials for programme and some chemicals, rentals (camp area), entrance fees (for excursions), common medicine, rewards and personal expenses. The mentioned fee is at the edge of expenses, on the other hand, it is at acceptable level for parents allowing participation of socially weaker children with interest in science.

Acknowledgements

The support of the Faculty of Science, Charles University in Prague, parents of the children attending the camps and project PRVOUK P42 is gratefully acknowledged.

References

Höfer, G.; Svoboda, E. (2006). Některé výsledky celostátního výzkumu „Vztah žáků ZŠ a SŠ k výuce obecně a zvláště pak k výuce fyziky“. In Moderní trendy v přípravě učitelů fyziky [online]. Srní: ZČU Plzeň, [cit. 20160508]. Available from: <www.kof.zcu.cz/ak/trendy/2/sbornik/svoboda_e/srni.doc>

Picková, M. (2012). (Ne)oblíbenost vyučovacího předmětu chemie u žáků na gymnáziích [online]. In Studentská vědecká konference Přírodovědecké fakulty Ostravské univerzity v Ostravě 2012. Proceedings of the conference. Ostrava: Ostravská univerzita, Přírodovědecká fakulta. [cit. 20130713] Available from: http://konference.osu.cz/svk/sbornik2012/pdf/budoucnost/didaktika/Pickova.pdf

Model of Teaching of Mobile Applications Programming in Non-Formal Education

Ľubomír Šnajder, Ján Guniš, Ľubomír Antoni

Slovak Republic,
lubomir.snajder@upjs.sk, jan.gunis@upjs.sk, lubomir.antoni@upjs.sk

Introduction

Nowadays, the mobile devices (MD) are part of the lifestyle of youth who use them for their communication, fun, education etc. In informatics education, we try to expand the role of pupils from consumer to producer of mobile apps. There is App Inventor from MIT that we consider as the most popular development environment for programming the applications (shortly apps) for MD. In the article, we focus on designing of a model of teaching of mobile apps programming in a non-formal education. The model was developed in a context of formal and non-formal education, because we shared and enriched our teaching experience from both types of education.

Methods

For designing a proposed model, we used the following methods:

– Analysis of the functionalities of MD and the development environment AI2.

– Content analysis of the teaching topic Algorithmic problem solving in State Educational Curriculum (shortly SEC) (National Institute for Education, 2014).

– Analysis of a content and the methods of teaching programming MD in AI2 (Wolber, 2015; McGrath, 2014; Beer, 2015; Turbak et al., 2014; Wolber, 2016).

– Action research in the groups of 13-14 years old pupils on informatics courses, in a university training and a further education of teachers of informatics in 2012-2016.

Based on the results of the above analyses and action research, we proposed the objectives, a content, the methods and the forms of teaching programming mobile apps in AI2.

Results

The proposed teaching methodology is based on the following principles:

– We focus on a programming of the compelling and useful (STEM) apps, which use the specific features of MD (the sensors, the touch screens, a mobility, etc.)

– The apps created by the pupils will be a part of their portfolios.

– We introduce a new program concept, if it is necessary for solving a problem.

– We emphasize a problem analysis and a subsequent design of solving.

– A basic version of an app should be created in a short time and then pupils could extend and enrich it individually in their interest.

We piloted our methodology during 5-days IT camp in July 2015. There were 15 pupils aged 13-14 years who attended the IT camp. A teaching programming took place 5 days in 2 90-minute blocks each day. During the first 4 days, pupils created 5 apps under the guidance of trainers (the authors of the article). The last day, they created and presented their own apps.

Based on the results of the above analysis, we propose the following contents of a 20-hour training. Pupils created the apps which cover a core subject matter described in our SEC:

– **Drawing pad**: The app draws circles on the spot where a user touches the screen.

– **Game Quick response**: The app records the time at which the user touches the ring which is repeatedly displayed on a random location of the screen.

– **QR quiz**: A user in the app scans the question using a QR reader and sends the response to the web server.

– **Generator excuses**: The app generates phrases such who-what-when-why-not done.

– **Game Labyrinth**: The app allows a user to direct the movement of the ball at the target position by adjusting the MD.

– In the end, pupils created own apps and presented them (e.g. pedometer, weather for given city, bookmark with personal links, or improved versions of previous apps).

In these apps were used following programming elements:

– **Components**: Canvas, Ball, Sound, Clock, Button, Barcode scanner, TextToSpeech, Web, TextBox and Label.

– **Sensors**: AccelerometerSensor and OrientationSensor.

– **Events of components (i.e. program inputs)**: Canvas.Touched, Clock.Timer, Ball.Touched, Button.Click, Screen.Initialize, BarcodeScanner.AfterScan, Web.GotText, AccelerometerSensor.AccelerationChanged, OrientationSensor.OrientationChanged.

– **Change of the components' properties (i.e. program outputs).**

– **Programming concepts and structures**: variable, changing the value of the variable, the variable in the expression, local and global variable, structured variable list, random numbers, condition, branching, cycle (only in a context of recalling the event handler), handling runtime errors.

– **Data structures**: number, text, logical value, color and list.

– **Problem-solving strategy**: decomposition of a problem into the sub-problems.

Discussion and conclusions

We consider this model of teaching as viable with the balanced programming and non-programming parts (4 hours vs 2 hours daily) and the balanced in-door and out-door non-programming activities. In comparison to informatics courses, the results of IT camp are more satisfying, e.g. better attendance of pupils and higher number of submitted apps. Due to the comparable content and allocated time for programming defined by the SEC and in the IT camp, we can consider using the model also in the regular programming lessons with some modifications – using worksheets and additional tasks to practice and strengthen pupils' knowledge and skills, e.g. in webpage http://ics.upjs.sk/~snajder/ai2/ (where source codes are in English, worksheets and methodologies in Slovak) and using the rubric for more precise apps evaluation (Sherman et al., 2014). We recommend programming STEM projects using sensors, which help to develop pupils' inquiry skills and knowledge of science and math (Šnajder&Guniš, 2015). For successful implementation of the programming of mobile apps to non-formal and formal education it is necessary to provide teachers with the appropriate support (training, guidelines, and worksheets for pupils, etc.)

Acknowledgements

This work was supported by EU Erasmus+ project 2014-1-DE01-KA203-000694, SciVis.

References

Beer, P. (2015). *Hello app inventor!: Android programming for kids and the rest of us* (1st ed.). Manning Publications.

McGrath, M. (2014). *Building Android apps in easy steps* (2nd ed.). In Easy Steps Limited.

Sherman, M., Martin, F., Baldwin, L. & DeFilippo, J. (2014). *App Inventor Project Rubric – Computational Thinking through Mobile Computing*. Retrieved June 28, 2016, from https://nsfmobilect.files.wordpress.com/2014/09/mobile-ct-rubric-for-app-inventor-2014-09-01.pdf

Slovakia, the National Institute for Education. (2014). *State Educational Curriculum for lower secondary – informatics*. Retrieved June 28, 2016, from http://www.statpedu.sk/sites/default/files/dokumenty/inovovany-statny-vzdelavaci-program/informatika_nsv_2014.pdf

Šnajder, Ľ. & Guniš, J. (2015). The Inquiry Based Approach in Learning of Mobile Applications Programming. In *Information and Communication Technology in Education. Proceedings* (pp. 211-221). Ostrava, Czech Republic: University of Ostrava.

Turbak, F., Sherman, M., Martin, F., Wolber, D., & Pokress, S. C. (2014, June). Events-first programming in APP inventor. *Journal of Computing Sciences in Colleges*, 29(6), 81-89. Retrieved June 28, 2016, from http://dl.acm.org/ft_gateway.cfm?id=2602739&ftid=1445118&dwn=1&CFID=637070108&CFTOKEN=79411060

Wolber, D. (2015). *App inventor 2: Create your own android apps* (2nd ed.). O'Reilly Media.

Wolber, D. (2016). *The App Inventor Course-in-a-Box*. Retrieved June 28, 2016, from http://www.appinventor.org/course-in-a-box-intro

Students' Understanding of Irreversible Processes

Libuše Švecová

University of Ostrava, Faculty of Science, Department of Physics, Ostrava, The Czech Republic, libuse.svecova@osu.cz

Introduction

The mass media provides a source of information on global climate change:

– The Washington Post (Warrick & Mooney, 2014) – *"Effects of climate change 'irreversible,' U.N. panel warns in report."*

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

– Czech news website Novinky.cz (2014): *"The impacts of global warming are likely to be severe and irreversible, a major report by the UN has warned"* (Dopady globální změny klimatu mohou být vážné a nevratné, varovala zpráva OSN).

The term *irreversible* appears in all three articles. Irreversible change often refers to processes that are irreversible and for which physicists use the term *irreversible processes* (Švecová, 2015). However, the terms *irreversible process* and *reversible process* do not feature in the Framework Educational Programme of the Czech Republic.

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

The Bulletin of the Atomic Scientists was founded at the University of Chicago in 1945 by a group of scientists who helped to develop the first atomic weapons as part of the Manhattan Project.

"They created the Doomsday Clock two years later, using the imagery of apocalypse (midnight) and the contemporary idiom of nuclear explosion (countdown to zero) to convey threats to humanity and the planet (Eden et al, 2015)."

"The Clock has become a universally recognized indicator of the world's vulnerability to catastrophe from nuclear weapons, climate change, and new technologies emerging in other domains (Eden et al, 2015).

Methods

We asked the question – *What misconceptions about reversible and irreversible processes do students have?* – as part of a survey carried out in 2014 to determine students' conceptions about both reversible and irreversible processes. In order to offer teachers a broader understanding of the many facets of environmental education, we conducted research into understanding irreversible processes among university students. Sixty-nine students participated in the survey, which took the form of a questionnaire. An anonymous, criterion questionnaire was created as the research tool. The questionnaire contained 12 items.

Results

The results of the survey show university students' misconceptions about *irreversible processes.* Gender distribution of the sample was as follows: 75% women and 25% men participated in the survey. The age range of the participants was 20 through 23. The aim of the survey was to determine university students' misconceptions about reversible and irreversible processes. The detailed results were published (Švecová, 2015).

- In total, 64% of students considered a refrigerator a cyclic heat engine and that the cycle consists of reversible processes (misconception).
- In total, 37% of students considered recycling an old vehicle a reversible process (misconception).
- In total, 77% of students considered recycling old paper a reversible process (misconception).
- In total, 47% of students considered plastic surgery of the eyelids a reversible process (misconception).
- In total, 45% of the 69 university students considered global climate change a reversible process; 55% considered global climate change an irreversible process.

The research results are linked to other research studies carried out in 2006 and 2008. The preconceptions of the students in our survey were not dependent on their respective educational levels, i.e. primary, secondary or university level.

Conclusions and Implications

Environmental education is a subject that is currently covered across the entire Framework Educational Programme for Basic Education in the Czech Republic. Environmental physics is a subject that needs to be incorporated into general physics education as a part of environmental education taught in primary and secondary schools. We propose that the *irreversible processes of thermodynamics* be integrated into environmental physics education in both primary and secondary schools in the Czech Republic.

References

Climate change: The possible effects. (2014). *BBC News: Science & Environment*. Retrieved from http://www.bbc.com/news/science-environment-26817593

Eden, L., Rosner, R., Ewing, R., Kartha, S., Kolb, E. R., Krauss, L. M., Lederman, L., Pierrehumbert, R. T., Ramana, M. V., Sims, J., Somerville, R. C. J., Squassoni, S., Wilson, E. J., Titley D., Rajaraman R. (2015). Three minutes and counting. *The Bulletin of the Atomic Scientists*. Retrieved from http://thebulletin.org/three-minutes-and-counting7938

Stover, D. (2015). Climate change: irreversible but not unstoppable [Online]. *The Bulletin Of The Atomic Scientists*. Retrieved from http://thebulletin.org/climate-change-irreversible-not-unstoppable8044

Švecova, L. (2015). *Nevratné procesy ve výuce fyziky*. Ostrava: Ostravská univerzita v Ostravě

Warrick, J., & Mooney, C. (2014). Effects of climate change "irreversible," U.N. panel warns in report [Online]. *The Washington Post: Health & Science*. Retrieved from https://www.washingtonpost.com/national/health-science/effects-of-climate-change-irreversible-un-panel-warns-in-report/2014/11/01/2d49aeec-6142-11e4-8b9e-2ccdac31a031_story.html

Změna klimatu dopadá na lidi stále víc a je nevratná, varuje OSN. (2014). *Novinky.cz*. Retrieved from https://www.novinky.cz/zahranicni/331987-zmena-klimatu-dopada-na-lidi-stale-vic-a-je-nevratna-varuje-osn.html

Indicators of Educational Results in Teaching Chemistry

Jan Tříska & Hana Čtrnáctová

Faculty of Science – Charles University, Prague, Czech Republic

Indicator is an observable fact which indicates the presence of un-observable fact. Indicators are usually used for monitoring and controlling. They are often used in the challenge of sustainable development. Gross domestic product (GDP) is an example of known indicator in the world. GDP is a monetary measure of the market value of all final goods and services produced in a certain period of time (quarterly or yearly). GDP are commonly used to determine the economic performance of a whole country or region, and to make international comparisons. Natality, mortality, the average age of people or acid-base indicators are other examples of often used indicators.

Indicators can be divided into three groups. Quantitative, semi-quantitative and qualitative indicators. Quantitative indicators are expressed by a numerical value or a percentage. It's for example GDP or natality and mortality. Semi-quantitative indicators are expressed by a value on the scale. It's for example satisfaction with the quality of education or health care. During the survey, respondents must express their satisfaction with this topic on a scale usually from one to ten. Qualitative indicators are dependent on subjective assessment of people. It's for example quality of life or school climate. During survey, respondents answer these questions.

At school we want to evaluate and verify educational results. How do we do that? In curriculum it's expected that students achieve certain objectives. As soon as we define expected outcomes, we should say how to verify them. One way of verifying expected outcomes of students is the creation of indicators of educational results. Learning exercises are good indicators for evaluating the quality of education. Created learning exercises validate various levels of subject matter and achievement of the expected outcomes of students.

Since 2005, a gradual curricular reform has been in progress at all education levels in the Czech Republic. New binding documents, called Framework educational programs, were issued for each type of school. These documents define so called key competencies, which the students must achieve during their education process, for example the competence to solve problems and others. In these documents, fields of education are divided into several educational areas. Field of chemistry is put together with physics, biology, geology and geography in the educational area called Man and Nature. For each field of education, curriculum and expected outcomes are concisely provided. Achieving the expected outcomes of students is obligatory for schools. That creates a problem, because Framework educational programs don't specify how these expected outcomes of students should be verified.

Czech curriculum is very brief. Schools have great autonomy in teaching, but it's difficult to compare teaching in various schools Our team at Charles' University in Prague focused on chemistry at grammar school level and we gradually processed the expected outcomes of students for general chemistry. In Czech general chemistry curriculum are these 4 expected outcomes:

– Students use scientific terminology to describe substances and explain chemical processes.
– Students perform chemical calculations and they apply them in solving problems.
– Students predict the properties of elements and their behaviour in chemical processes based on their knowledge of periodic system of elements.
– Students use their knowledge about structure of compounds and chemical bonds to predict the properties of chemical compounds and their behaviour in chemical processes.

We have created detailed expected outcomes for the topic of general chemistry. These detailed expected outcomes are divided according to different levels of Bloom's taxonomy of educational objectives into three groups: knowledge and understanding, application of knowledge and higher levels of acquisition of knowledge. These detailed expected outcomes were created for the topic of basic chemistry calculations:

Knowledge and understanding

– Students define basic chemical parameters - amount of substance, mass, volume, density, molar weight, molar volume, molar concentrations, they write their relationship definition and the base unit.
– Students explain meaning of these parameters with own words.

Application

– Students solve simple examples of using formulas or proportion.
– Students convert units of various chemical parameters.
– Students are able to search in the periodic table of constant values of properties of elements.

Higher level of knowledge

– Student analyse the chart of some chemical parameter and he determines the properties of substances from a chart.

Each level should be accompanied by an indicator – model learning exercise. We are going to create them. Learning exercises will be focused on the practical application of knowledge from chemistry and they are varied in terms of content and formulation.

The created learning exercises are going to be verified at grammar schools in the Czech Republic during 2017 and 2018. During this process, the levels of achievement of expected outcomes of students, which are defined in the Framework educational programs, will be established.

References

Impact of an Experiential Approach upon the Development of Science Teaching Skills within Student Teachers in Francophone Minority Communities*

Louis Trudel[1], Abdeljalil Métioui[2]

[1]Université d'Ottawa (Canada, ltrudel@uottawa.ca), [2]Université du Québec à Montréal (Canada, metioui.abdeljalil@uqam.ca)

Introduction

At the last survey conducted by the Program for International Student Assessment (PISA 2012) undertaken by the countries members of the Organisation for Economic Co-operation and Development (OECD), Canadian students of minority education systems have scored significantly lower in science compared to their counterparts in majority education systems (CMEC, 2013). To remedy this situation, it is important that training programs prepare future teachers (FEs) in Canada to meet the challenges of science education in minority communities by offering them a training approach seeking a better balance between theoretical and practical training (Scharmann, 2007).

To this end, we propose an „experiential" approach to science education training in minority settings in which student teachers (STs) are encouraged to explore their representations about the science teaching and learning during lived experiences in these settings, to reflect on these experiences by linking them with prior knowledge, and to begin the process of inner transformation of their representations to improve their teaching skills in minority communities (Seed, 2008). In this regard, our research aims to determine the impact of implementing such experiential training approach to science education upon the development of science teaching skills within student teachers in francophone minority communities.

Methodology

the experiential approach was implemented in two science education teaching courses during the fall session in 2014 by a member of the research team of a francophone education faculty in the province of Ontario. To be accepted in the program, candidates must hold a bachelor's degree in science or a related discipline. The syllabus of these courses gave student teachers the choice between the experiential approach described here and a more traditional approach. The

*This research is funded by the Social Sciences and Humanities Research Council (SSHRC) of Canada

choice of the school was made on the basis of its proximity to the Faculty of Education, which allowed volunteers to get there easily without affecting their studies. The science education professor held a doctorate in science education and had spent several years teaching science in high schools. As practicum supervisor, he became interested in various aspects of teacher training in science education. The experiential approach is the result of a thought process over several years which had its foundations in his teaching activities as science teacher, educator and supervisor (Trudel & Métioui, 2010).

Regarding qualitative methods used in this research, the diary written by a member of the research team was used to determine the conditions for implementation of the proposed approach in the target environment (Altrichter & Hollly, 2005). Moreover, we collected documents produced by STs when planning activities for the school (e.g. lessons plans, videos, etc.) to determine how well those activities were fit for use in practice. Other documents were collected to describe the characteristics of the school settings and specify the contexts in which took place the implementation of the project. These documents were mainly emails exchanged between the participants, documents presenting the project to schools, and the letters exchanged between representatives of the school and faculty. Regarding the qualitative data collected, we followed the method developed by Miles and Huberman Saldaña (2014) to classify data in predetermined categories or create new categories.

Results

We present here results of the implementation of the experiential approach in the Francophone schools in Ontario, focusing on identifying difficulties encountered, implementation processes, and adaptation of educational tools conceived by our STs to the context of selected minority communities. Upon presentation of the project to the director of the school and science teachers, several objections were raised by the participants. The first one was about the safety of students at school because they would likely interact with our STs. Was there insurance and appropriate security measures taken to prevent incidents? There was also some confusion between the experiential approach and a practicum. In this regard, several teachers were concerned about the additional burden their involvement in the project, such as supervising STs, could bring to them. After answering all of the school‘s concerns, the research team was informed later that a science teacher had decided to participate in the project implementation in the school. Given that this teacher was very active in scientific projects, and additionally enrolled in a master‘s program in education, the research team estimated that it would be a welcome addition as project coordinator in the school. This role also gave him the motivation and the necessary funding to organize the activities of our STs in school.

These activities consisted in participating to tutoring sessions with pupils after classes, designing critical thinking activities in science, creating videos to teach students the concepts of science and mathematics and planning protocols for science laboratories. All volunteers STs (13) chose one or more of these activities to complete their twenty hours required for their participation in the project. To supervise their work, the teacher-coordinator had set up a Google account where STs could upload their work and get feedback from her and their university professor. According to their comments, STs enjoyed their involvement in the community, which had allowed them to become familiar with the characteristics and needs of teaching in minority communities sciences. However, some STs lamented about the lack of time that did not allow them to explore sufficiently the different ways a specific activity may take in its implementation in the classroom. Consequently, activities that have made our STs for school were appreciated by the teacher but she considered that they will need to be refined before she could include them in her practice.

Discussion and conclusion

To implant the experiential approach in minority schools, it is important to address the concerns expressed by stakeholders in this environment. They should also agree on the rules of collaboration, and chose a school speaker who can bridge the gap between the two communities (Scharmann, 2007). Furthermore, the use of information and communications technology (ICT) had allowed us to promote interaction between participants (Graham, 2013) and facilitate feedback with respect to the conception of activities by STs (Instance, Vincent Lancrin, Van Damme, Schleicher & Weatherby, 2012). Finally, time constraints and scheduling, both by practicing teachers and STs, require a balance to be struck between the demands of university science education programs and the needs of minority education settings (Bruno & Chaliès, 2011).

This research has helped us identify certain conditions to set up in order to implement an experiential approach in Francophone Minority Schools and assess qualitatively its effect on the development of science teaching skills within student teachers. Regarding the limitations of this research, they include the convenience of site selection and the voluntary nature of participation that does not allow us to generalize the findings beyond the chosen site and our sample. We intend in future research to test the robustness of our results to other sites.

References

Altrichter, H. & Hollly, M.L. (2005). Research Diaries. In B. Somekh et C. Lewin (Eds.), *Research Methods in the Social Sciences*, chap. 2. Thousand Oaks (Californie): Éditions SAGE.

Bruno, F., & Chaliès, S. (2011). Optimiser les dispositifs de formation des enseignants novices par alternance: étude de cas. *Revue des sciences de l'éducation*, *37*(3), pp. 465-487.

CMEC (2013). *À la hauteur : Résultats canadiens de l'étude PISA de l'OCDE, Le rendement des jeunes du Canada en mathématiques, en lecture, et en sciences, Premiers résultats de 2012 pour les jeunes du Canada âgés de 15 ans.* Disponible sur le site : http://www.cmec.ca/211/Programmes-et-initiatives/Evaluation/Programme-international-pour-le-suivi-des-acquis-des-eleves-(PISA)/PISA-2012/index.html

Graham, M.J. (2013). *Google apps meets common core*. Thousand Oaks (CA) : Corwin.

Instance, D., Vincent-Lancrin, S., Van Damme, D., Schleicher, A., & Weatherby, K. (2012). Preparing teachers: Delivery of 21st century skills. In Schleicher, A. (Ed.), *Preparing Teachers and Developing School Leaders for the 21st Century: Lessons from around the World*, (pp. 33-54). OECD Publishing.

Miles, M.B, Huberman, A.M., Saldaña, J. (2014). Qualitative data analysis: a methods sourcebook, 3rd ed. Los Angeles, Califorinia: SAGE Publications, Inc.

Scharmann, L.C. (2007). A dynamic professional development school partnership in science education. The Journal of Educational Research, 100(4), pp. 235-242.

Seed, A.H. (2008). Cohort building through experiential learning. *Journal of Experiential Education*, 31(2), pp. 209-224.

Trudel, L. & Métioui, A. (2010). *Étude exploratoire d'une démarche de formation sur la planification d'une stratégie d'enquête en physique par des futurs enseignants*. In C. Couture et L. Dionne (Eds.) : Formation et développement professionnel des enseignants dans le domaine des sciences, de la technologie et des mathématiques: Recherches et approches novatrices. Ottawa : Les Presses de l'Université d'Ottawa.

Interactivity in Education

Zuzana Václavíková

University of Ostrava, Faculty of Science, Department of Mathematics
zuzana.vaclavikova@osu.cz

Formal and informal education

According to Krieck (1922), people learn unconsciously through work, art, language and culture. All communication between human beings is educational. When we use term "education", usually it means that a teacher and learner are needed. Formal education is normally provided by trained teachers in a systematic intentional way within school. Informal education is the part of one´s development the comes about outside of formal education. It is realized in family, peer group, by mass media and by the institutions of informal education (library, museum, science center, and so on) – by subjects whose main role is not education. A new form of pedagogical thinking during the late 1920s and 1930s developed the idea of science museums: interactive models, demonstrations, and objects to be touched – "hands-on" principle, as a contradiction to the traditional "hands off" signs in museums (Salmi, 1993).

In a general point of view (dictionary.com), interactive means acting upon or influencing each other; allowing a two-way flow of information between a device and a user, responding to the user's input, if users receive real-time feedback.

In the area of education, respectively digital technology, we usually mean by interactivity the possibility of establishing an active connection with the machine or technological device when the device is able to respond to stimulus that gives the user some connection between the human object and device that enables a two-sided flow of information, actions and reactions.

The degree and character of this communication may, however, be different. Thanks to the technological possibilities in the learning concept, interactive is understood primarily as ICT. But digital does not necessarily mean interactive in a deeper sense and interactive, as mentioned, is not always an ICT product.

An interactive learning material or tool, for example, could be a computer game that requires certain inventiveness, but also a building kit (for example in physics) or a static object that arouses the senses. It could be also an educational program, learning module or other activity without the "device" you work with.

Types of interactivity

The action-reaction process can occur once or the communication can work in several steps. A one-step interactive object is, for example, an exhibit demonstrating some mechanical or optical phenomena where, by launching balls a track, the experiment is finished. Multistep interactivity can be seen in computer equipment, the student, according to a set of information, is asked for an action which, in turn moves the set of information on. In the case of one-step interactive tools a general process is presented, a phenomenon that is always the same. After realizing and understanding, the pupil does not need to repeat it. The multistep interactive device may have, due to the information "tree", more alternatives for action and reaction and it can be played repeatedly.

We can also discuss the level which the interactive element is working on – physical, intellectual or emotional. A well-designed interactive element pervades all these levels.

The physical level is usually the first step of the interactive element, it starts the communication. The intellectual level is the bearer of an educational feature. The primary target is to think about the process, establish the questions and start to find the answers. An interactive tool never gives the answers to the question without the process of thinking. The emotional level is often neglected, although its role is no less important. The role of this level is motivation for further investigation or discovery. Emotional level may be in addition to visual performance, which strongly influences our first impression, supported by non-educative elements (graphic, topic and so on). An example is the educational computer game MinecraftEdu, based on the principle of the well-known and popular commercial games.

One misconception is that complicated, expensive and commercially made interactive tools are better. It is always important to reflect the age of the target group. Young learners don´t need professionally processed products, they are happy with simple tools that may be improvised at home.

How Science centers work

The majority of interactive exhibits in science centers are professional products on very high level of design and quality. There is a brief instruction of what you have to do with the exhibit and a short explanation of the phenomena (often QR code for the further information). But that is only the start. In the Science and Technology Centers in Ostrava we use an interactive idea in our supporting program for schools which mainly consists of three parts: study modules, Your idea – Kids and Science program and we use the LARP game as an educational tool. Now we have experience with more than 40.000 children.

The education modules are linked to the exhibits and develop the phenomena the exhibits are about. The module is usually 2 or 3 hours and is based on the idea of creative science (Václavíkova, 2015), includes production of one item or one experiment which can be implemented anywhere – at home, at school, with friends or in a science center. In terms of the time, it involves motivation, device production itself and feedback (comparison of products, discussion about modification options, etc.). At the present time we offer approximately 20 active modules targeted to mathematics, physics, chemistry, biology, new technology and robotics and 20 new modules are in the preparation stage.

Your Idea – Kids and Science is a unique license of the Netherlands Kids and Science Foundation focusing on the development of technical knowledge of primary school students. The "Inventor class" is a week-long program aimed at the whole class with exact time planning and fixed goals – to make inventors out of the students in 7 days and to introduce them to the entire process, starting from having an idea, via a prototype production up to an appropriate marketing campaign (see www.kidsandscience.org).

The LARP (Live Action Role Play) is in the form of a game where the participants represent fictitious parts (with precisely defined characters) of a prepared story and they create and perform the story themselves. Even though the major educational theme is generally provided, knowledge from other fields will be needed during the game as well. The LARP game is guided by animators who form part of the story, too. In order to meet the educational requirements, a perfect preparation of both the story itself and material and technical facilities during the LARP is inevitable. At the present time we offer 2 LARPs and 2 new are in the preparation stage.

References

Krieck, E.. (1922). *Philosophie der Erziehung*. Jena. Eugen Diedrichs Verlag.

Salmi, H.. (1993). *Science Centre Education. Motivation and Learning in Informal Education*. Research Report 119. Dept. of Teacher Education, University of Helsinki.

Václavíkova, Z.. (2015). *Creative science – the way how to improve the knowledge and skills of children*. Mathematica V. Ružomberok. Verbum. Scientific Issues. 91-96.

Field-Based Research Projects in the Polish Biology Olympiad

Maria Zachwatowicz, Marcin M. Chrzanowski, Joanna Lilpop

University of Warsaw, Faculty of Biology, Warsaw, Poland
m.zachwatowicz@uw.edu.pl, m.chrzanowski@biol.uw.edu.pl,
j.lilpop@biol.uw.edu.pl

The context and purpose of the framework

One of the conditions required to participate in the Polish Biology Olympiad is to prepare the students' research project. According to the Rules of Procedure of the Olympiad (Rules of Procedure of the Polish Biology Olympiad for the years 2013-2016), such project should be an experiment or observation conducted by the student on his/her own in the field, at home, at school or at other institutions.

In the current study, we focused on the students' competences to plan and conduct the research projects based on a fieldwork.

Methods

We examined 40 randomly selected field-based research projects submitted to the competition of the Biology Olympiad in the school year of 2014/2015. We analysed the appropriateness of the course of research, as well as the most frequently encountered errors. We prepared a summary of the problems observed. We present the results of our survey.

Results

We discovered the following set of major problems in the students' research projects:

Students' Titles

– The title does not reflect or reflects only partly the content and/or the scope of the project.

Students' Introduction and Aims

– Lack of hypothesis, lack of research questions.
– The aims of the study formulated in the 'Summary' part only.
– Inconsistency of the research goals with the content and course of research;

– Unrealistic research aims given the time frame available (e.g. temporal dynamics requiring a long term study).

– Cited works of other authors show that the research problem being under consideration has been already solved.

Students' Methods

– No (or vague) information on the study area.

– Lack of information on the criteria for sampling-sites selection, sampling criteria and number of replications.

– Insufficient input data, sampling size and/or number of replications.

– Lack of statistical analysis of the results.

– Conducting observations for a part of the growing or breeding season only (which may generate incomplete results and influence their accuracy).

– Comparative studies differing in the selection criteria for sampling sites.

– Lack of controls or the control sample differing in characteristics in comparison to the research sample (e.g. a number of specimens, their age, etc.).

Students' Results

– Partial and selective reference to the results obtained.

– Inventory works missing a complete list of species.

– Empirical studies missing the quantitative data.

– Incomprehensible tables and charts.

– Inadequate types of charts and/or incomplete data presented on the charts.

– The results presented as a set of charts and tables missing any comment on their content.

– Lack of clear, explicit conclusions.

– Invalid or unjustified conclusions (e.g. drawing sweeping conclusions based on the results for only a part of growing or breeding season).

– Factual errors and misconceptions.

– Facts and data belonging to 'Methods' and 'Results' placed as a part of the 'Discussion'.

– The results being compared to the results of other authors without making sure on the comparability of the methods for both of the studies.

Other observations

– Lack of location maps (or maps present but incomprehensive, missing the scale and the North direction).

– Inaccurate or inconsistent literature citations.

Conclusions and implications

Students' research projects often manifest major shortages regarding the planning of the research process. Students need schooling, more practice and direct leads on how to conduct reliable research projects and how to present them in a proper way.

There appears a need to elaborate a comprehensive guide for secondary school students and their teachers on how to conduct the field-based research projects. Such a guide is currently being prepared under the auspices of the Chief Committee of the Polish Biology Olympiad.

Acknowledgments

Authors would like to acknowledge the members of the Chief Committee of the Polish Biology Olympiad: Piotr Bębas PhD DSc, Łukasz Banasiak PhD and Elżbieta Auguścińska MSc for providing the input data used in this survey

References

Rules of Procedure of the Polish Biology Olympiad for the years 2013-2016.

Kinesthetic Teaching & Learning in Daily School Practice – How Do It?

Paulina Zimak-Piekarczyk

Doctoral Studies in Natural Sciences at the Polish Academy of Sciences in Cracow, Joseph Conrad Social Gymnasium and High School STO in Zakopane, Gymnasium POSA in Zakopane, paulina.zimak@gmail.com

Introduction

Nowadays the world around us is dynamic, a lot of information flows for newer applications and different way. Teaching and learning is changing, as needs change. Young people expect and show a greater interest to explore information in an active way. Education strategy, which was implemented in gymnasium and high school in Zakopane, is the strategy of teaching science through scientific inquiry and discovery (IBSE, called Inquiry Based Science Education) in conjunction with the kinesthetic and artistic approach (Zimak, 2013, 2014). The aim of it was to demonstrate the opportunities offered by the coherence of active teaching-learning in daily school practice during the biology and chemistry education.

Methods

The article presents examples of sequences of photos of modelling bio-chemical processes used within the natural learning in our school. It is recommended especially for students of modalities: visual or kinesthetic in the framework of the questionnaire VARK learning styles [www.1]. The impact of learning-teaching styles on education processes Nodzyńska (2008a, 2008b) revealed in her research. In school education during biology and chemistry lessons we learn molecular genetics construction, nature laws, mechanisms of life, including osmoregulation in cells, tissues, organism like fishes, elements of blood antigenes-antibodies and their interaction, some diseases like diabetes and its types, anatomy of organisms etc. Students have a lot of problems with micro world imagination and understanding processes. We try to solve the problem by connecting science-art modeling (Fig. 1).

Life processes

What is the mechanism of this process? How can they live in water? What is osmoregulation?

Problem questions – easy answer, when you explain it in visual-kinesthetic way.

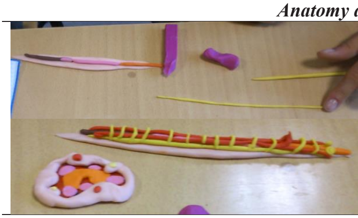
Human body & physiology

Create and play in Your own games. Learning by fun is good solution on repetition lessons to exercise and check knowledge.

Serological conflict, blood transfusion, immune system working can be present using handmade elements of blood antigenes-antibodies. It is easier to explain their interaction.

Pupils' animations of some diseases like diabetes and its types in comparative studies show the main difference between them.

Anatomy and morphology step by step



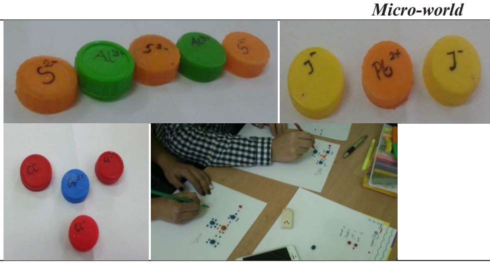
What is in the middle of organisms? How are they built? What organs and systems are in them?

Sequence plasticine models can help in learning.

Cells world

Students learn about cells by creating their models. They use different materials like jelly beans, poppy seeds and corn, Chinese noodles, fruits and vegetables as equivalents organelles. They learn about their appearance and placement in cells. 2nd Mendel's law can be explained using magnets - Pupils can see random and independent movement of gene allels located in different pairs of chromosomes during the formation of gametes.

Micro-world



Using plastic caps of beverages we explain the structure of various chemicals for example: acids, hydroxides or salts etc. Students can observe that atoms/ions have different sizes, electric charge. They can „feel" a microworld – the 3D geometry and the arrangement relative to each other.
Plasticine allows us to show the electronic structure and octet and double rules. Colour of element is contractual – atoms / ions are colourless.

Figure 1. Examples of practical solutions of kinesthetic teaching and learning in daily school education.

Results

Pupils were eager to create the structure of jellies, magnets, plasticine, cap beverages, computer animations as well as they willingly watched and participated in interactive demonstrations. They could create and watch some sequences of processes to better understanding. During our interactive show we analysed problematic questions, what was helpful in learning and understanding. Pupils started to work in team, they discussed and exchanged insights. They felt responsible for task assigned to them. Similar observations had Kamińska-Ostęp (2014) in her IBSE research, using the teaching method by discovery.

Conclusion and implications

In school, teachers and students should try to modify their approach to education processes. They should check kinesthetic technique in daily practice. It is important to indicate young people effective and active ways of learning, developing new skills and understanding around world. During lessons they ought to more often...

References

Kamińska-Ostęp A. (2014). How to use cleaning products in an effective and safe way? realization of the module PROFILES using teaching method by discovery - IBSE [In] Nodzyńska M., Kopek-Putała W. (Eds.) Profits and Limitations of Inquiry Based Science Education, Cracow: Pedagogical University. pp. 43-47. ISBN 978-83-7271-882-2.

Nodzyńska, M. (2008a). Czy różne style nauczania/uczenia się wpływają na poziom wiedzy uczniów? [In] Nesměrák K. (Ed.) Current Trends in Chemical Curricula. Proceedings of the International Conference, Prague, 24-26 September 2008: Charles University. Faculty of Science, pp. 61-66.

Nodzyńska, M. (2008b).Zależność pomiędzy zastosowanymi stylami uczenia a osiągnięciami uczniów [In] Híc P. (Ed.) Acta Facultatis Paedagogicae Universitatis Tyrnaviensis. Séria D, Vedy o Výchove a Vzdelávaní. Supplementum 2, Aktuálne vývojové trendy vo vyučovaní chémie. - Trnava: Trnavská univerzita. Pedagogická fakulta, pp. 49-53.

Zimak, P. (2013). Odkrywanie i poznawanie przez uczniów szkół gimnazjalnych i ponadgimnazjalnych świata nauk przyrodniczych w ramach strategii IBSE [In] Nauczanie przedmiotów przyrodniczych kształtujące postawy i umiejętności badawcze uczniów. Część 2. Kraków: Uniwersytet Jagielloński, pp. 97-109 ISBN 978-83-921505-2-7.

Zimak., P. (2014). IBSE Strategy in Connection with Art: Discovery Biological Contents and Processes by Modelling in School Education Practice [In]

Nodzyńska M., Kopek-Putała W. (Eds.) Profits and Limitations of Inquiry Based Science Education, Cracow: Pedagogical University. pp. 43-47. ISBN 978-83-7271-882-2.

[www.1] www.vark-learn.com

Contents