Teaching and Learning Science at all Levels of Education

the monograph edited by:
Paweł Cieśla, Anna Michniewska

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Introduction

The devastation of the environment, the climate changes, the rapid development of the industry require that people should be more aware of the phenomena occuring in nature.

On the other hand, natural sciences are considered by the students as a difficult, difficult to understand and thus not many people choose this way of education. Therefore, a special special attention should be paid to the theories, methods, teaching tools and teaching aids in science education. This monograph includes a section with theoretical considerations as well as section devoted to motivation of students to learn and the ways of activating students in order to their learning be more effective.

In addition, there are chapters devoted to research and other various aspects of teaching and learning of individual science subjects at various levels of education.

In this publication there is also a chapter concerning the research on textbooks for teaching the sciences.

Although the ways of teaching of various subjects are distinct, however, a number of solutions can be applied in teaching not only to teach the particular subject but also other sciences, so their statement in one monograph allows for a broader look at nauuczanie different science subjects.

Teaching and Learning Science – Theoretical Considerations

HOW SCIENCE WORKS

Jan Novotný, Jindřiška Svobodová

The purpose of this article is to introduce a new module course "How Science Works" that focuses on the scientific ideas with their wider contexts. This module course was established especially for future and present science teachers, especially physicists. As learning tool and study support was developed textbook, where students can get realistic ideas about methodology used by scientists to question, investigate, predict, gather evidence, and propose explanations. This course is intended to assist participants in better understanding of the importance of science point of view. The philosophical background of science is preliminary presented there, for example role of paradox, proposition and conjecture in the generation of knowledge in science and implication of science.

The context and purpose of the framework

Recently, there are many debates about appropriate educational approaches for scientific thinking for improving teaching in school science. We can reasonably assume that scientific thinking can provide skills for cognitive development of young persons. Those skills can be transferred to other learning and general social contexts.

We intended to compile course program which could help solve the problem: how can we show our students (pre-service science teachers) the real nature of science? The module "How Science Works" is proposed for 12 units, it includes lectures, discussions and assessment activities. The implementation of the module involves many steps that are rearranged to the needs of individual lectures, teachers or students. Each developed unit was reviewed, and it will be tested in practice this year.

The innovative course objectives are:

a) Introduce students (pre-service science teachers) on science and research methods.

b) Explore the science approach, assumptions and philosophical arguments.

c) Develop their critical thinking and argumentation skills.

d) Present science as a discovery process that allows to link facts into coherent understandings of the natural world.

e) Consider the ethical and social aspects of science research.

At the end of this course, student should be able to demonstrate understanding of scientific approach; he can formulate scientific arguments with respect to their consistent structure (hypothesis, expectation, and observation) and principles for known theories. Student can use no only standard scientific methodology, but they can use historical thought experiments, paradoxes and can identify argument fallacies. They can clarify some themes of characterizing scientific reasoning and the structure of theories. Student sees relations between the precise and the elementary description of selected science phenomena and he is able to formulate elementary treatments of those phenomena and to explain their adequacy. Final assessment includes student's essay on selected problem-based science scenarios, where more complex situations could be found. Assessment is given us serious reflection for future module plans, application and methods.

Methods

The objectives of innovative course for future science teachers are similar to general aims of every science education. The whole module content is designed for shift to more active learning instructional strategies. Active learning strategies are used to engage participants in thinking critically or creatively, speaking with the entire group, for expressing ideas through writing, giving and receiving feedback. The lecturer for innovative course "How Science Works" monitors student understanding and can maintain student's attention by activities.

The authors of the module program produced guide textbook with title "How Science Works". They make an effort to explain in this textbook what science is, how it works, and how it is related to other disciplines and society. The guide provides step-by-step introduction to the science relationships to situations around all of us and offers training on the critical thinking. There is a compromise between the depth and range of material authors wish to cover, and what students are able to successfully accept in the module time available. There are many explicit questions and open ended problems for each topic, so lecturer can talk with pauses for prepared activities.

Using several examples authors demonstrate steps of the science picture of the world from a crude phenomenological description, via the qualitative analysis to the first steps of exact quantitative explanation. These conclusions can be confronted for selected specific problem in physics with popular elementary treatments. Students try to find the optimum level of simplification in real problem case. Authors also have tried to expose to misconceptions in common science interpretation. Text provides information about the science demarcation, differences between good science and pseudoscience. The meaning of this course lays in combination of interpretation and discussion on selected science methodology or science relation topics, whereas bigger relevance is put on discussion. Students could evaluate following questions and many others: What is that if we say "scientific discipline"? Can science explain everything? Has the ideal of science been changing? Should the scientist interpret, evaluate or change his surroundings?

Application and Results

The first problem we meet, how to explain, what exactly is science? It is difficult to define term science precisely, philosophers were arguing about it for decades. For classical scientists, the aim of science discovery was to gain true and certain knowledge and understanding of the world. Such knowledge is only possible where the objects themselves are precisely defined, unchangeable. Moreover, the modern term "science" is now applies to a broad set of human endeavor.

Is it science?

Prepared activity allows students to explore proposed criteria for considering whether a propounded statement could be accepted as science result. There is neither a simple clear distinction, nor a consensus yet. The purpose of the activity is to find a student's own demarcation criterion, how he need to distinguish science from non-science. Then on the basis of the selected criteria, student considers proposed statement to be or not to be scientific and why. They have got starting concept:

1. Scientists deal with events which can be observed, measured, and tested; they must be able to use their senses to observe directly or indirectly and evaluate phenomena.

2. A valid scientific theory offers a well-defined naturally occurring cause mechanism which explains why or how a natural event (phenomenon) occurs.

3. The processes and methodology of science are very successful in dealing with problems within the limits of science. Science does not have the answers to all of the questions in the universe, or the solutions to all human problems.

4. The realm of science is limited to solving problems about the natural world. Science is not properly equipped to handle the supernatural realm, nor the realm of human values.

ACTIVITY 1 Is it a scientific statement?

The following distinguishing criteria are suggested for this student's activity in advance:

Objectivity (observable real-world evidence), Testability, Universal Relationship, Predictability, Natural cause for explanation.

Students have to comment these sentences – statements:

Green plants convert sunlight into energy.

Extraterrestrial beings have visited Earth.

The Universe is not static but expanding.

The sun stopped in the middle of the sky and delayed going down about a full day.

Lecturer asks the students and they create summary notes:

What is the difference between science and non-science statement?

Try to determine several criteria limited studying problems by science, explain how each criterion is satisfied or not satisfied scientifically.

What do we mean by evidence? How do you think an evidence-based explanation is different from other explanations?

If statement is non-scientific, does it mean that the statement is not true?

Argumentation Skills

Argumentation is a collective cognitive development process which involves using evidence to support or refute a particular statement. Argumentation has great potential especially for students' communication skills. We observed that mutual debate proves plausible reconstructions of scientific conceptions.

The scientific argumentation is different from argumentation that takes place between people, which is based no only on tangible evidence, but involves opinions, beliefs and emotion. It mustn't concentrate on attacking the opponent person. The goal of a common dispute is for one person's point of view to "win" over another's. In scientific argumentation, however, explanations are generated, verified, communicated, debated, and modified. Ideally, the goal of all participants in scientific argumentation is to refine and build consensus for scientific ideas, based on evidences, to come as close as possible to understanding the reality of the natural world.

To facilitate students' start - disputation, each topic activity is designed to initiate by question or problem. Student successively submits his logical arguments supported by relevant evidence and introduces his own line in the debate. He seeks to distinguish fallacy in opponent argument.

ACTIVITY 2 Fallacies and Argumentation

Students have to become conscious of reasoning in arguments in which:

Facts and conclusions do not follow logically from the evidence given.

A used analogy is not suitable for discussed problem.

The control groups of samples are very much like the experimental group.

Identify

Error in reasoning in: „Since scientists cannot prove that global warming will occur, it probably won't."

Logical fallacies in worksheet text

Write list with at least five different examples of faulty reasoning you meet.

Ethics

As more influential science becomes, the more ethical issues become associated with scientific practice and research directly. Scientist requires not only a specialized scientific knowledge but an appreciation of the ethical dimension of science. Scientists need to be able to recognize ethical dilemmas and formulate coherent responses to them more than ever before. But scientists are not philosophers or ethicists.

The ethics approach may be puzzling to a natural science student. It's usual that there is no one correct answers to ethical dilemmas. Discussions are open-ended and can seem be very subjective. In the ethics interpretative work is required and the ability to critically evaluate a diversity of views including one's own. Students need to develop an appreciation of some of the key features of ethics in order to operate ethically in science. They have to improve their reading skills, thinking carefully about the meaning of each text. Ethical standards are also a inner part of scientific research.

ACTIVITY 3 Ethics

Students have to formulate their answers or work on problem sets in teams, and submit one set of solutions per team.

Can science pass a value judgment? Why so, or why not? Based on what reasons?

Describe types of unethical behavior of science professionals.

Find at least one area of human activity that is open or not open to abuse.

Note the newspaper reports, on which you can ask ethical question?

Did you know ethical principles that guide scientific research today?

What is my role and responsibility in being a scientifically literate citizen?

Conclusions and implications

The authors believe that science teaching can be improved if teachers know basic progress steps of the history, philosophy and ethics of science and if these topics are casually included in the science curriculum. The history of science, as a way of knowing, has an important role in many of the theoretical issues that educators need to address: how science should be taught in traditional cultures; how scientific literacy can be promoted; and the conflict which can occur between science education and religious or cultural values and knowledge. Science and technology have done wonders in many fields, but many human problems remain.

The authors hope that thanks to completing this course, students – future teachers - will acquire and extend their critical thinking and science literacy. They hope that mutual students' debates will prove plausible reconstructions and better understanding of scientific conceptions and problem-solving skills. Support materials for this course show how science can be appropriately used to inform wider society.

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SYNERGY OF NEW MEDIA AND SCIENCE EDUCATION – EVOLUTION AND PARADOXES

Katarzyna Potyrala

Introduction

In 1955 communication was interpreted as: [1]'communicative activity rare with the tools use' and [2] 'exchanging the ideas and knowledge trough speech, writing or signs [Oxford English Dictionary]. From 1980s of the 20th century the media convergention is improved and process of its digitalization is still open. In 1991 the notion 'cyberspace' or 'World Wide Web' have not been included into main book devoted into new technology: Technology 2001. The Future of Computing and Communication [Leebaert, 1991] although prefix 'cyber' was created earlier by science fiction writers: William Gibson [Neuromancer, 1984] and Stanislaw Lem [Cyberiada, 1965]. Neuromancer developed visionary concepts of artificial intelligence, virtual reality, genetic engineering, displacing the traditional nation-states by large corporations and cyberspace, in a book called the matrix long before these ideas became a frequently-used term in popular culture. Gibson also addresses the problem of dehumanization of the world dominated by universal and cheap technology. Cyberiada is a series of Stanislaw Lem's short stories set in the world of robots. Did they think about avatar world?

Internet appeared in 1990, when Tim Berners-Lee created the language of computer-dimensional HTML. It combines different texts, images and sounds, and thus enables the creation of databases with the interactive access. It means that regardless of location, sites and web pages are at your fingertips. Rapid spread of the Internet has affected the whole society.

In 1999 six aspects of communication were described: transmission, understanding, influence, connecting, social interaction and exchange of meanings among people [Goban-Klas, 2000]. The content and scope of the notions 'media' means among others: mass media - the tools of information; the tools of mass information emphasizing the mass nature of transferred information; the tools of mass communication suggesting mass communicating so they assume partial feedback between the receiver and the sender; mass tools of social influence suggesting lack of the feedback [Gajda, 2005]. Media and hypermedia as means of communication facilitate such a course in which participants of the transmission encode and decode meanings, use the information while also creating it at the same time. According to McLuhan [2004] there are two types of media: hot and cold (hot: short cuts, reduced, aggressive, radio, photo; cold: rich, multilateral, speech, TV). Main criteria of media classification are connected with the intention of sender, kind of code, kind of message, kind of receiver, topics, kind of scientific approach and…different aspects of process of communication. Models of communications are metaphors. Communication requires feedback as well as sender, receiver and an message.

New media has changed the way the current life, both in the field of entertainment, art, education, social contacts and the labour market. The network has become a kind of revolution. It takes place here and now – in front of our eyes.

In 2010, Levinson formulated the thesis that each consumer is simultaneously a producer of information and new new media are community in nature. Information is an objective and not a form of communication [Potyrala, 2011]. Application of media in education must be developed.

Methodology of Research

The main aim of the research was specifying the tendencies of changes in the approach to educational media and describing the directions of development media-aided biology education in the face of the contemporary culture's challenges.

The following research problem was formulated: What is the main direction of educational media evolution in the range of biology teaching and learning? The research hypothesis assumed that educational media don't take into account the challenges of contemporary culture and they are overheated which is a reason for their small effectiveness in metacognitive competence of students.

The main research method was data analysis concerning the research carried out by author in 2000-2013 in the range of media-aided biology education. In the guide to data analysis such criteria of evaluation were used as: research design, type of media, students' competence (effectiveness of media-aided teaching and learning), conclusion and recommendations. Additional research method was case study, analysis of the selected media connected with using biological knowledge and its promotion by the website devoted to visual art for expanding cognitive perspective of the research.

Results of Research

Analysis of the data connected with the application of the new media in biology education

The steps of the research regarding the application of ICT in biology education were mainly connected with:

/1/ specifying of the degree of teachers' preparation to undertake the problems of ICT-aided science teaching: teachers' skills, conditions of teaching with ICT methods and aids used [Potyrala 2000; Stawinski & Potyrala, 2000]; analysis of the curriculum issues and the scope of the curriculum issues requiring ICT use (e.g. interactive tasks) [Potyrala & Walosik, 2002; Potyrala, 2003],

/2/ specifying the influence of the strategy of teaching in the area of biology knowledge on the quality of student's knowledge, skills and attitudes [e.g. project method] and importance of media education [Potyrala, 2005, Potyrala & Walosik, 2005; Potyrala & Wolek 2005],

/3/ the different ways of communication in biology education in the face of European standards [Potyrala & Wolek, 2007]; strategies of forming students' critical thinking in the face of new technologies during biology lessons [Potyrala& Walosik, 2007]; from cognition to metacognition [Potyrala, 2007, Potyrala & Walosik, 2008],

/4/ 'school as learning organization' and strategies of dialogue in media-aided biology education [Potyrala, 2008; Potyrala,2009],

/5/ information and communication competence of biology teacher in the face of social and educational changes [Potyrala & Walosik, 2010],

/6/ e-learning platform in blended–learning [Potyrala & Jancarz-Łanczkowska, 2011],

/7/ the impact of media culture on the biology education of 'instant generation' [Potyrala, 2011]; learning 'in the cloud' and students' ways of information searching [Potyrala & Jancarz-Łanczkowska, 2013].

The relations between undertaken research problems are presented in the Figure 01.

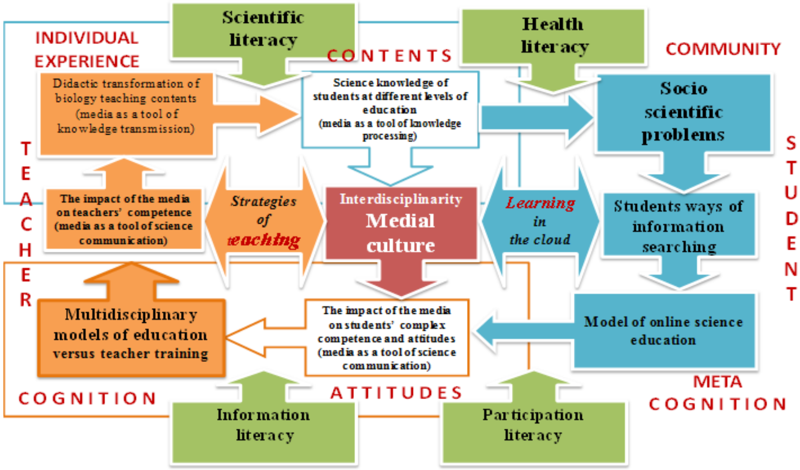

Fig. 01. The relations between the research problems in 2001-2013

The ways of didactic transformation of teaching contents in biology with computer use were the main topic of the research which was carried out in 2000-2002. The main aim of the undertaken research was an attempt to find the answer to the question regarding the influence of the manner of realization of curriculum issues in biology on the students' achievements in this respect.

The author's concept of didactic transformation of genetics teaching contents at the junior high school level was to develop a spiral structure of genetics contents, i.e. grouping the teaching material in consecutive cycles. Within the research on the problems of didactic transformation of the biology contents [especially in genetics] at the level of junior high school the author developed computer programs [Potyrala & Chorazki, 2002] The simplest of them provided only some information through a drawing, animation or written word, and sometimes they supervised the degree of their learning. Slightly more difficult programs allowed the students to, for instance, actively participate in the course of an experiment regarding the generations of hybrids, the degree of revealing a given characteristic or the calculation of gains and losses resulting from specific activities. These programs could also provide the teacher with auxiliary elements in preparation for the lessons – a collection of illustrations and other materials may be used in lesson plan, students' papers. Charts with tasks could be used for a written revision test in the given issues. It was the author's aim to make interactive elements of the program support the buildup of knowledge and the process of shaping notions, reinforced research, independent searching and processing of information and increase the intensity of working on particular problems, and thus increase the students' attention and ability to memorize.

All of computer programs created by the author were electronic version of problems and tests contained in 'student work charts'.

Tasks of this type required revealing the following abilities by students:
• associating the contents of a specific task and the more general natural problem,
• formulating hypotheses regarding predicted solutions and research methodology scheme,
• perceiving practical importance of the performed task.

In theory a biology teacher had numerous possibilities of applying ICT at lessons, especially, that elements of ICT-aided education were taken into consideration in the curriculum basis, curriculums and assumptions of inter-subject educational medial path. In practice proper use of these tools encountered numerous difficulties.

In the next step, biological education in experimental classes was carried out with searching methods such as work with various sources of information, modeling, laboratory method, all of them in problem strategy with ICT application. Problems performed by students at lessons in the experimental group and appearing in student achievement test are presented in Table 01.

Tab. 01. Problems performed by students at lessons in the experimental group and appearing in student achievement test

Student’s activities	Type of situation tasks
collecting information and interpreting	Theoretical problem, aiming at control and evaluation of the ability of integrating knowledge in various scientific areas and systematizing it in adequate structures.
communicating	Problem controlling and evaluating the ability to communicate in various situations
hypothesis posing	Decision-making problem, requiring the students to solve a problem situation on the basis of the possessed scientific knowledge
creating concepts and theory checking	Control tasks, aiming at control and correction of problem situation
controlling	Problem aiming at control and evaluation of the degree of mastering the knowledge and skills regarding planning and predicting results of undertaken theoretical and practical activities

It was assumed that the criteria of evaluation of the biology teaching computer programs have to be created in the connection with conception of these programs and the scope of teaching contents biology in at the different levels of education. The teaching contents should be functioning together with the other contents or with some interactive tasks. So suggestion of introduction to the educational computer programs the structure of knowledge makes the processes of analysis and synthesis possible.

In connection with the hypothesis that new media support the development of metacognitive competence in students, the metamodel was created [2007]. This approach was grounded on the theoretical perspective of how people learn, as it was discussed in „How Pople learn” by Bransford, Brown & Cocking [1999]. New technologies were used in five ways: 1/bringing exciting curricula based on real-world problems into the classroom; 2/providing tools to enhance learning; 3/ giving students and teachers more opportunities for feedback, reflection, and revision; 4/building local and global communities that include teachers, administrators, students, parents, scientists, and other interested people; and 5/ expanding opportunities for teacher learning.

The research allowed to conclude that:

• learning environments must be learner- centered to engage learners in meaningful activities so that they can reflect, evaluate and refine their initial thinking,
• learning environments need to be knowledge – centered, so that students can develop deep and true understanding of the subject matters and use this knowledge to solve complex problems in authentic and real-world contexts,
• learning environments must be assessment – centered so that learners can be provided with plenty of opportunities to correct their alternative concepts and improve their thinking, while they are still in the process of learning,
• learning environments must be community – centered so that learners can feel that they belong in a community of learners they can trust, cooperate with and negotiate understanding.

The new role of teacher was taken into account. It was underlined that teacher should be facilitator of learning [students and teacher collaborate to problem solve and critically think about contents, learners can use the content in the same way that experts in the real world use it]. Community members collaborate to problem – solve, debate about different points of view and come to negotiations about what constitutes valid scientific knowledge and authentic science.

In the research [2008-2009] the presentation of possibilities of forming students' critical thinking about complex subject issues during environmental protection lessons at high school level was attempted. It was a part of a more extensive research connected with application of ICT tools at biology lessons. However, it was also concerned with the influence of new strategies of dialogue on the development of students' competence in the area of sustainable development. The theoretical part of research focused on the strategies of forming students' point of view and attitudes. The practical part of research was connected with the organization of teaching and learning for sustainable development and application of the selected teaching strategies support students' questions, their new ideas and arguments. The authors underlined that relationship between science and the essence of biological knowledge, connection between knowledge and life, relationship between science knowledge and culture, improvement of professional opportunities and permanent education are very important in education for sustainable development. The research showed the influence of ICT tools on educational process as well as the need for improvements of methods and techniques of biology problems' communication. Communication in education is treated in connection with the tools, it does not put appropriate attention to the ways of scientific mediation and communication and the strategies of dialogue which promote transformation skills of scientific knowledge and using the procedural knowledge.

The research in 2011 was a part of more extensive project connected with the data processing by students of secondary school in the context of lifelong learning. The main aim of the research was to examine the conditions of student's motivation to learn according to the original learning program with use of e-learning platform [Moodle]. It was assumed that introduction of e-learning at the stage of school education motivates students to undertake further education through biological distance learning platform.

The research undertaken theoretical and practical analysis of the trends in biological education, what was presented in the following conceptual framework: /1/ from cognition to metacognition, /2/ from individual experience to community, /3/ from knowledge to attitudes, /4/ from diagnosis to prevention, /5/ from subject skills to life skills. Experimental tests and analyses were designed to verify the research hypothesis assuming that media culture has the influence on biology education of 'instant generation'. The most important seems to be that special attention should be paid on students' individual social needs, how to inspire interest in a variety of areas, to achieve success due to new and creative ways to solve problems.

The research conclusion are the background for the recommendation for school practice [Table 02].

Tab. 02. Research conclusion and recommendation for practice of teaching and learning

Term study & Conclusion	**Recommendations**
2001-2002: The way of transforming biology knowledge (with media use) influences students' achievements positively	Teachers should apply suitable strategies and methods, which will help students not only to form scientific views, but also to use the knowledge and skills they have at further stages of education and in everyday life
2003-2004: Media use in the realization of project method seemed fully justified.	Media-aided project method must be organized in accordance with the scheme: from involvement, through exploration and transformation of knowledge, to presentation of products and reflections
2006: The communication tasks with computer use made biology contents easier for the students and let them to identify the problems and making plans for solving them.	It is indispensable to adapt the teaching contents take place in computer programs or Internet's sources of information to student's age and abilities of knowledge processing and communication.
2007: Existence of "ready-made biological problems" and "ready-made ways of solving those problems" and even "ready-made solutions" does not go well with preparing students for a real confrontation with problems of the information society.	The old concept of problem-focused teaching has to be revised in the situation when particular stages of this strategy are implemented "in different time and place."
2008-2009: New media multiply experience and thus constitute an important part of educational environment.	Information Technology can be a stimulator of the changes in education towards "school as learning organization" refers to people (teachers and learners) who participate in the process of changes ('be'), develop the ways of thinking ('know'), build strategic partnerships ('do') and have the motivation and capacity to learn ('learn')
2010: Communication in education is treated in connection with the tools, it does not put appropriate attention to the ways of scientific mediation and communication and the strategies of dialogue which promote transformation skills of scientific knowledge and using the procedural knowledge.	The phenomenon of knowledge transfer must be perceived in a complex manner and transformed due to the changing motivations, ways of information reception and mechanisms affecting the content interpretation (numerous patterns of behaviour, transience of views, instability of systems).
2011: 1/ Blended learning motivated to learn biology by an interesting form of classes.2/Media culture means universal access to information, metacognitive skills are necessary to information processing, media culture is the culture of social networking media, media culture forced to have the life skills.	1/ The basis of the effective e-education is sending reminder mails to students, verbal coaxing during stationary classes, awarding every activity, answering all of the students' questions and providing exhaustive feedback. 2/ The alternative ways of teaching (e.g. art), including negotiation of shape of the reality with students of high school are possible during biology lessons. It can be the basis of new educational models of 'instant generation'.
2013: The studies have found generally that students are ready to 'learn in the cloud' and the Internet and Web Social Network are their natural environment of problems communication (including scientific, biological and environmental issues).	Contemporary school has to take into account all components of the model of learning in the cloud, it means e.g. existence of community of learners and new strategies and methods of education.

Case study – examples of the connection between science and visual art

Through a colorful projects created by the network, the art has been re-discovered. And because of the contemporary network art, science is re-discovered [e.g. „Weightless" http://www.flickr.com/photos/dancecamerawest/page4], „Millimeters Matter" http://creativity-online.com/news/pick-of-the-week-samsung-millimeters-matter/124526, „Life Spacies 2" http://90.146.8.18/kiev/en/projects.asp].

Classic work of new media art is "The Handphone Table" [Laurie Anderson 1978]. In this installation, visitors sit at the table and covers his ears. Only then will they hear sounds that are conducted by the wood and bone. Groundbreaking work of interactive art is undoubtedly the "Interactive Plant Growing," by Christa Sommerer and Laurent Mignonneau. It was first demonstrated at the festival of art, technology and e-communities in Linz [1993]. Artists engage technological and biological processes. The recipient must take the role of interactive gardener. Further work in this pair is "Life Species" [1997] - an installation showing a simulation of fight between species and "Life Species 2" [1999], in which viewers can bring to life certain creatures by typing text becoming the genetic code. After reaching a certain size and finding a partner with the same genetic code they will be able to reproduce. These projects are among the art, bioart-dealing with the relationship between nature, technology and art.

Many artists have undertaken issue of gender identity and the human sexuality, illness and death, disciplining of the body. Thus art began to move the intimate areas of human life. With the development of cyberspace it has changed our perception of physicality. Currently in the network, we can find examples of unconventional programs such as "Cyborg's Sex Manual" by Polish artist in the field of new media Piotr Wyrzykowski [„Cyborg's Sex Manual" http://1.1.1.4/bmi/csw.art.pl/new/gif99/cbsx0.GIF]. In this, a kind of "artistic game" cyborgs are the characters – a combination of a highly technologically advanced machines and humans. With their participation there be erotic acts, which are the modern and convenient form of sexual education for young people.

Final conclusion

Analysis of the basic science knowledge and skills necessary for people in 21st century opened more vast area of the study on 'scientific literacy'. The violent development of ICT-aided methods and strategies of biology teaching is dated on 2002-2003. The research connected with the students' attitudes towards science & new technology had a starting point in 2004. In the same time the works on the level of 'information literacy' necessary for teachers and students for undertaking the pedagogical innovations were improved. From 2005 classical media had been developed and more often were described as new communication media.

Theory of lifelong learning education was a reason for preparing the model of learning supported by ICT (metamodel]) Metacognitive competence of students seemed to be more important than cognitive competence so new strategies of learning as critical thinking and situated learning were proposed [2007]. It was a good starting point for new didactic solutions as e.g. dialogue methods and new role of biology/science teacher's creation [2008-2009].

New new media gave new opportunities for science communication, mediation and knowledge processing due to social networks and platforms of communication [2010-2011].

In order to examine the challenges facing the biological education one should bring some contexts of contemporary culture that has a significant impact on shaping the identity of young people and their lifestyle. Human moves in an entirely different reality-virtual reality, the creation of unlimited space. Art has to use these possibilities…

The changes in technology and culture are the reason for necessity of the changes in the approach to media application in education and consider the impact of new media and new new media for students knowledge and attitudes [Figure 02].

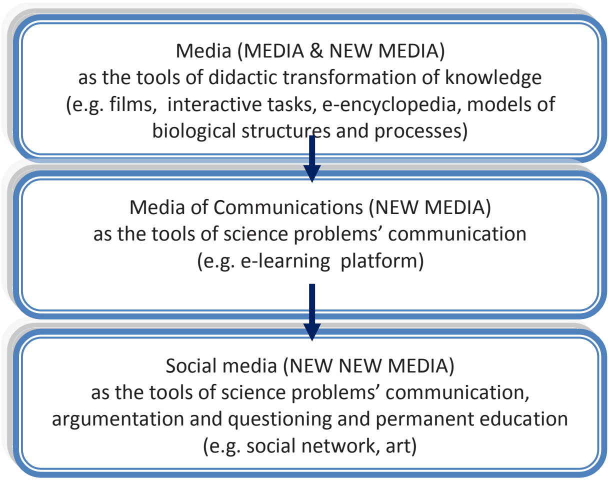

Fig. 02. Transformation of media

Technology alone does not create art. Technique is only a tool. By analogy - school alone does not create the attitudes and knowledge. School can help to explain the world, but it needs new tools which facilitate the priority direction: from cognition to metacognition, from knowledge to attitudes, from diagnosis to prevention, from subject skills to life skills.

At the same time new tools and engaging the young people in knowledge processing show the natural ways from individual experience to community. They show the necessity for creating a new standard of literacy which means participation literacy.

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THE ROLE OF DIAGRAMS IN SCIENCE LEARNING AND AN UNEXPECTED RESULT

John Oversby

Background

While textual explanations can be very powerful in both narrative and analogical form, visualisations have formed a bedrock of communication about scientific concepts, systems and objects for a long time, particularly at the primary and secondary school levels. Indeed, the availability of visualisations would seem to indicate that their role is not only obvious but essential in constructing the whole picture of what may happening and why. Yet, our experience is that visualisations can pose a challenge to learning. This challenge arises because a visualisation can not contain every aspect of what is to be explained, may contain elements whose functions and rules may be unknown to the reader, may contain elements that are simply not seen by the reader, and whose subtleties of structure are too often missed by the reader. The PALAVA teacher researcher group has long been intrigued by these issues and has sought to investigate what is going on, as far as they can. In the first place we have sought to characterise carefully what we mean by a diagram, and then to develop methods of investigating research questions that have interested us. Although often neglected in accounts, methods are central to successful insights.

Visualisations are regularly presented in textbooks and presentations yet there is relatively little research on how they are perceived and on their effectiveness. Topsakal & Oversby(2012a, 2012b, 2013) have reviewed research on the role of diagrams in their studies in biology education. The Reading (UK) teacher researcher group (known as PALAVA) has adopted this theme in their current research. This work is based on that theme. The data here was collected from science teachers and researchers.

What is a diagram?

Fathulla K & Hammed S (2009)

Research on the nature of diagram is sparse.

Research on how diagram supports learning is sparse.

Osborne JR (2005)

Diagram is defined as an abstract machine for constructing arguments.

Diagrammatic models construct a visual language and represent what is difficult to express in prose.

A diagram is a visual representation of navigational trails of narratives of a process or ideas

Perini L (2005)

Philosophy of science focuses on linguistic explanation and not diagrammatic explanation.

Diagrams are simpler and more comprehensible that the equivalent text.

Diagrams are symbols, as well as containing symbols.

The PALAVA research has these research questions:

What distinguishes diagrams from illustrations and other pictorial representations?

What do individual observers notice in diagrams?

What characterises the process of individuals constructing diagrams?

What characterises the processes of groups constructing diagrams.

Methods

This was a desk-based literature study followed by discussion with teachers.

Observers were audio-recorded in a think aloud process, which was discussed by the group.

Videos of individuals were discussed by the group.

A science activity was rehearsed by the teachers: a collaborative diagram was created by three teachers who were observed by the rest.

Methods details

What do observers see in a diagram? The method is fairly simple: a diagram is presented and the participant tells about what is seen which is then recorded. The recordings are presented to the PALAVA group who discuss their thoughts, filtering the thoughts that do not meet challenges, until no new thoughts are forthcoming. This is called saturation.

How do participants construct a diagram? Again the method is straightforward. As an example, we asked individuals to construct a diagram to show distillation (we did not differentiate between simple distillation and fractional distillation) while being video recorded. The videos were shown to the group as in the saturation example above followed by collaborative analysis.

How do participants construct a diagram collaboratively? The method is a little more complex. A surprising practical experience was shown to the group, who then took part in repeating the experience in pairs. Three volunteers then constructed a collaborative diagram, without text, to explain to someone in the next room how to conduct the experience. We chose, at this stage, not to ask them to explain the experience since we discovered that they had some difficulties in doing so. The other group members made field notes of the discussion. This was then followed by a 'saturation' discussion involving both the diagram constructors and observers.

Results

The literature research produced a characterisation of the essential features of a diagram.

Diagrams are made up of a variety of features, such as lines (straight and curved), arrows of various kinds, shapes filled with shading and/or colours, text as labels or legends, symbols and icons. The location of such features was also a feature, as was the significance of empty space.

Individuals have a limited range of observations of complex diagrams. Individuals often construct diagrams strongly influenced by their prior subject knowledge. I discovered in the task for Q 4 (with N =1245) that science graduates manipulated practical activities to fit what they thought would happen, and (N = 6) were unable to construct a collaborative diagram to describe to others what to do.

Conclusions and implications

I have provided a useful characterisation of what constitutes a diagram for research studies. Observing and constructing diagrams is rarely taught and is then poorly carried out. These science graduates did not conduct one science investigation objectively. Two groups of science teachers and researchers were unable to construct a collaborative diagram if they did not understand what was happening. Explicit teaching of diagrams could improve teachers' capacity for using diagrams in learning about science.

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Activation and Motivation in Science Education at all Levels

PRELIMINARY STUDIES ABOUT KNOWLEDGE AND APPLICATIONS OF MNEMONIC METHODS BY POLISH PUPILS, STUDENTS AND TEACHERS

Kamil Jurowski, Małgorzata Krzeczkowska, Patryk Własiuk, Anna Jurowska

The context and purpose of the framework

Young people continuously receive countless amounts of information. Effect of redundant relevant information implies the necessity of correct selection, organization and ignorance of repeated information. What do we do to remember even some of them? Calendar and tablets with different applications play important role, sticky notes system as well. All of them bring order to the information. Extremely valuable is skill of proper structuring of the material to remember. This skill can be developed in a wide variety of courses of mnemonic devices, as well as the courses teaching techniques for fast memorization. The question is: What is the success of these techniques, the success of the courses? When you store data, such as numbers or historic dates, without using mnemonics, the left hemisphere of the brain is activated first and foremost (this part of the brain is responsible for logic and reason). Creative right hemisphere remains unused. Mnemonic techniques can release potential of right hemisphere, which is much more efficient at storing than the left hemisphere. Dynamic synergy between right and left hemisphere allows applying imagination and association in the process of memory. The success of mnemonics is achieved when pictures, movement, fun and usage of senses is added to the memorization process.

The word “mnemonic” derives from the Greek goddess of memory – Mnemosyne (Fig. 01), and means “memory enhancing”. Simonides of Ceos is considered to be a father of “mnemonics”.

Fig. 01. Greek goddess of memory – Mnemosyne.
[http://neoskosmos.com/news/sites/default/files/2011/September/MNEMOS.jpg]

Mnemonic (“nee-moh-nick”) techniques, also called a mnemonic strategies, mnemonic devices or mnemonics, are systematic procedures designed to improve our memory [Guthrie, 2002] Hence, mnemonic strategies ought to be understood as systematic procedures for intensification of memory. The main idea of mnemonic strategies is application in developing better ways to encode (take in) information, so that it will be much easier to retrieve or remember [Mastropieri & Scruggs, 1998]. Therefore, mnemonic devices can be attended as learning strategies which can often enhance the learning and later recall of information [Bellezza, 1981] . The main task in developing mnemonic strategies is to find a way to connect new information to information students have already locked in long-term memory. If pupils or students make an enough strong connection, the memory will last a very long time, because the mnemonic strategy had carefully linked it to things that will be very familiar according to these procedures can be extraordinarily effective [Mastropieri & Scruggs, 1998] . Moreover, the mnemonic strategies can be incorporated for the elements that require recall, what is both advantage and disadvantage of this method. These methods are also useful way of improving memory in students, who exhibit difficulty with remembering things. Hence, the mnemonic devices do not represent an educational panacea, but can be an important component in improving memory and learning or teaching process.

It is very probable that people forget what they have learned very quickly, if they have not enough strong connection between think and something very close/personal [Bower, 1970]. Due to this fact, people need tools to aid recall.

From the point of view of education, many sources evidence that pupils and student, who are using mnemonics method, also perform better on comprehension tests [Mastropieri, Scruggs, & Fulk, 1990]. Moreover, using of mnemonic devices often results in very high levels of recall performance. These methods operate by the use of cognitive structures, but on the other hand these methods are characterized by low or lack of relation to the conceptual content of the material being learned and also they are focused only on certain aspects of their operation [Bellezza, 1981].

From the point of view of didactic, the mnemonic methods can be considered to be a strategy for organizing and/or encoding information with the sole purpose of making it more memorable [Bellezza, 1981]. Hence, these organizing and encoding operations can be discussed with respect to how these operations use and create cognitive cuing structures. These cognitive cuing structures usually are made up either of words or visual images in the form of sentences or rhymes. Their main goal is to act as mediators between the signal to the learner to recall and the information to the remembered [Bellezza, 1981]. Very important and main part of learning strategy, using mnemonic method, is connection the information to be remembered with one or more cognitive cuing structures. The application of the cuing structures is later used by the learner to recall the information through a self-cuing process. It must be emphasis that, the cuing structure used to remember a set of information is often not conceptually related to the information it cues. Moreover, when comprehension enhancement is called for, it is important to consider using specific comprehension strategies, such as content elaboration, prior knowledge activation, manipulation, coaching and questioning, or prediction and verification [Mastropieri & Scruggs, 1998].

In consideration of all earlier presented and discussed aspects, in Table 01 we present advantages and disadvantages of mnemonic methods.

Tab. 01. Advantages and disadvantages of mnemonic strategies.

advantages	disadvantages
memory strategies; procedures for intensification a memory; extremely effective in helping people to remember things; own prepared mnemonics by students outperform the results in comparison to students in free-study conditions; often better enables information to be retained in memory; is not as dependent as a memory schema;	are not a teaching and learning methods; are not a comprehension strategies; low or lack of relationship between the conceptual content and the material being learned; are focused only on certain aspects of their operation; students' performances may be lower than when teachers supply the strategies;

The analysis of Table 1 show, that the mnemonic devices are characterized by numerous advantages, but also with not less disadvantages. It seems that, the application of this kind of didactic tools can be groundless or outright dangerous for teaching and learning with understanding. Unfortunately, this is truth that these methods do not characterize the understanding of the problem. However, the expandable development of the science, the extreme quantity of facts and material required to the memorization demands findings and using the methods making possible quick and permanent memorizations or associations of the information. Due to this fact, using and application of mnemonics techniques in science teaching and learning is fully justified.

Due to the number of distinctions the various types of mnemonic methods can be made, but there is a lack of suitable, clear and well known (modern) classification and nomenclature system of those mnemonic methods. For classification system it is very important that, the basic distinction is that between mnemonics that primarily involve organizing operations and those that primarily involve encoding operations. Hence, an organizing operation is one that associates or relates in memory units of information that at first appear unrelated [Bellezza, 1981] . What is more, an encoding operation transforms a unit of information into some other form, so that it can be fit into some organizational scheme.

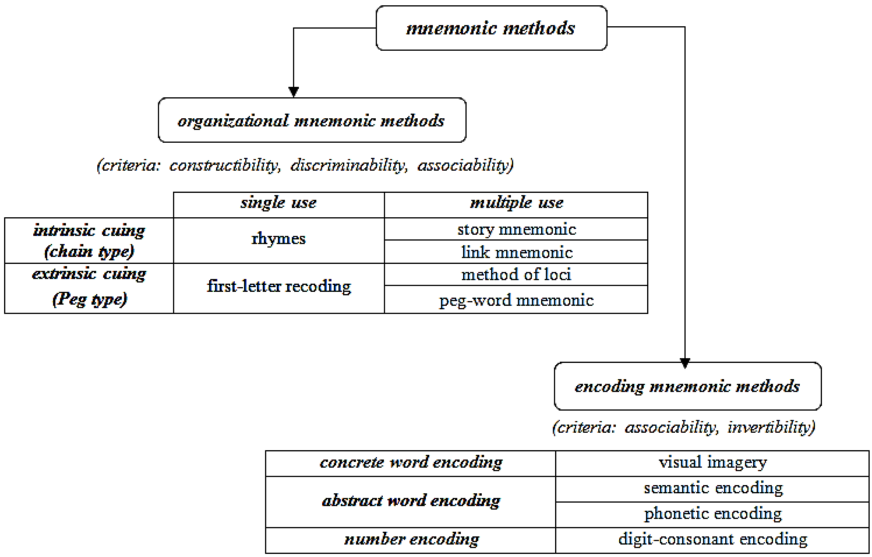


Fig. 02. Classification of mnemonic methods - based on Bellezza (1981).

Information presented in Fig. 02 allows understanding the main ideas of mnemonic devices in English literature. In contrast to that, the common usage of mnemonic devices does not exist in polish education. Theme of our interests corresponds to the usage of mnemonic methods in Poland. The first step of our activity was to review the Polish literature about mnemonics and to find as many mnemonic, associations with education as it is possible. It was found that there are not many studies strictly related to mnemonic devices. Moreover, articles that were found are mainly concerned with the use of mnemonic devices in teaching of spelling and grammar, language teaching and in teaching of mathematics (especially for school students with some dysfunctions).

Nowadays, the variety of courses offered to school students, students, teachers and other in order to improve the quality of the memory process are very popular. In bookstores we can find many items on fast memorization, rapid learning and mnemotechnics. It must be emphasized, that the mnemonics are reflected even in the topic of Bachelor thesis [e.g. Matelska, 2012]. One of the chapters in the national report on ‘visual learning’ status in Poland is devoted to mnemonic devices [Szpilska, 2006]. The analysis of this report indicates the need for teachers awareness and familiarization with possibilities offered by the application of mnemotechnics. Czerniawska & Ledzińska [1994] state that ‘the allegation of low efficacy [of mnemonics] has not been confirmed in studies, moreover, the applicability of these strategies gains increasing interest’. In our preliminary research (as the second step of our activity) we tried to find answers to the next questions: Do the teachers know mnemotechnics? Are they using mnemonic devices? Have they participated in mnemocourses?

Methods

In order to acquire an understanding about the subject of the mnemonics methods use among targeted groups, relevant questionnaires were prepared in several versions adjusted to particular target group. The survey was conducted in May – June 2014 period and the answers were collected using online survey tools and the traditional (paper – see Fig. 03) questionnaires were also prepared. The latter were filled during teacher's school meetings or workshops (e.g. SAILS project) and during classes with pupils and students. In Table 02. information about groups of respondents is presented.

Tab. 02. The characteristics of the surveyed groups of teachers, pupils and students. The numbers are in percentages.

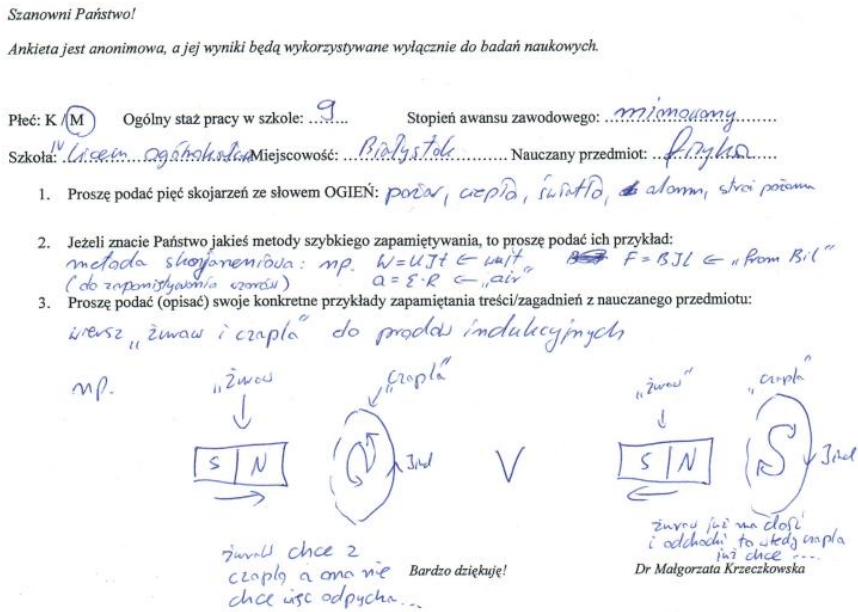
<table>
<tr><td rowspan="6">TEACHERS</td><td colspan="2">SEX</td><td colspan="4">PROFESSIONAL DEGREE *</td><td colspan="5">LENGTH OF SERVICE IN THE TEACHING PROFESSION [YEAR INTERVALS]</td></tr>
<tr><td>M</td><td>F</td><td>PR</td><td>CN</td><td>AP</td><td>CR</td><td>0-10</td><td>11-15</td><td>16-20</td><td>21-25</td><td>>25</td></tr>
<tr><td>80</td><td>20</td><td>0.00</td><td>9.78</td><td>19.56</td><td>70.66</td><td>22.83</td><td>16.30</td><td>17.39</td><td>22.83</td><td>79.35</td></tr>
<tr><td colspan="11">TAUGHT SUBJECT</td></tr>
<tr><td colspan="3">chemistry</td><td colspan="2">biology</td><td colspan="2">physics</td><td colspan="2">mathematics</td><td colspan="2">other **</td></tr>
<tr><td colspan="3">35.04</td><td colspan="2">22.63</td><td colspan="2">26.28</td><td colspan="2">4.38</td><td colspan="2">11.67</td></tr>
<tr><td rowspan="3">STUDENTS</td><td colspan="2">SEX</td><td colspan="5">AGE [INTERVALS]</td><td colspan="4">EDUCATIONAL LEVEL ***</td></tr>
<tr><td>M</td><td>F</td><td>8-11</td><td>12-14</td><td>15-18</td><td>19-24</td><td>>25</td><td>PS</td><td>LS</td><td>UP</td><td>HE</td></tr>
<tr><td>72</td><td>28</td><td>0.41</td><td>19.06</td><td>63.11</td><td>15.78</td><td>1.64</td><td>1.02</td><td>32.17</td><td>57.38</td><td>9.43</td></tr>
</table>

*Professional degree: PR – probationary teacher, CN – contract teacher, AP – appointed teacher, CR - certified teacher.
**Educational level: PS – primary school, LS – secondary school (lower), US – secondary school (upper), HE – higher education
***informatics, natural sciences and a variety of vocational subjects

Results

Only 12% of teachers that were asked about whether they participated in courses designed to present memory enhancement techniques answered that they had. Among them, only a quarter holds the certified teacher degree and a half holds a contract teacher degree. The majority of teachers group is composed from certified teachers meaning that they achieved the highest professional degree what seems to correlate with theirs length of service in the teaching profession. Nevertheless, it appears that the least experienced apprentices of educational system are familiar with memorization techniques. This is also reflected in the group of teachers who responded negatively to the aforementioned question. Only 13% of contract teachers and over 70% of certified teachers did not attend such courses. This trend reflects the growing trend in recent years in the mnemonic techniques which is inversely associated with the professional degree of teachers.

Qualitative attempt to analyse the survey results in terms of the investigating specific examples of mnemonics among teachers highlights the following fact. Most of the teachers interviewed to provide specific examples served them incompetently. The examples given were related to the means through which mnemonics should be delivered rather than to serving mnemonics with concrete examples. These improper elements comprised primarily dictation notes, their colour indication of text importance and another. Teachers, who reported examples of mnemonic devices, served them predominantly in connection with the subject they teach. This may be due to the fact that in their teaching practice they are using such techniques on a daily basis, in particular, serving them to the students. The group of teachers performed better when a question to provide a name of specific mnemonic techniques has been asked. Mainly they enumerate methods such as: mnemonic linking system, peg system and method of loci. The teachers were also asked if they encountered any examples of mnemonic devices in textbooks. Only few examples were indicated as such, and they were originating mostly in physics textbooks.



Szanowni Państwo!

Ankieta jest anonimowa, a jej wyniki będą wykorzystywane wyłącznie do badań naukowych.

Płeć: K / M Ogólny staż pracy w szkole: 9 Stopień awansu zawodowego: mianowany

Szkoła: IV Liceum ogólnokształcące Miejscowość: Białystok Nauczany przedmiot: fizyka

1. Proszę podać pięć skojarzeń ze słowem OGIEŃ: pożar, ciepło, światło, alarm, straż pożarna
2. Jeżeli znacie Państwo jakieś metody szybkiego zapamiętywania, to proszę podać ich przykład:
metoda skojarzeniowa: np. W=UJt ← „wait" F=BJL ← „from Bil"
(do zapamiętywania wzorów) a=ε·R ← „air"
3. Proszę podać (opisać) swoje konkretne przykłady zapamiętania treści/zagadnień z nauczanego przedmiotu:
wiersz „żwaw i czapla" do prądów indukcyjnych

np. „żwaw" „czapla" S N Jind V „żwaw" „czapla" S N Jind

żwaw chce z czaplą a ona nie chce iść odpycha...

żwaw już ma dość i odchodzi to wtedy czapla już chce...

Bardzo dziękuję! *Dr Małgorzata Krzeczkowska*

Fig. 03. Scan of the survey completed by physics teacher from Białystok.

Among the group of students, the vast majority are taught in a traditional school, and less than two percent are students who are being either home-schooled or taught with Montessori method. Eight percent of students have attended coursed devoted to the memory enhancement issue. It is a smaller proportion than in the group of teachers, which is probably the cause of the fact that teachers can participate in such courses through local professional development centres, while the commercial courses are available for students. Students, like teachers, confirm the existence of mnemonic devices examples in textbooks, but these examples relate mainly to biology and foreign languages textbooks. Despite the difference in this aspect, students report significantly more names of specific mnemotechnics, for instance: mnemonic linking system, peg system, method o loci, mnemonic major and dominic system. Students also seem to be more familiar with the subject of mnemonic devices because they serve more sophisticated methods than teachers, such as the rhymes, songs, creation of chronological images. Both students and teachers think of mnemonics as an association technique what seems to correspond well with the definition of mnemonic devices. Students, however, give more proper examples, which may indicate that such mnemonic devices are created by them in order to ease the learning of a large portion of assigned material. Some of these examples are consistent with those which are provided by teachers (for example endothermic and exothermic reaction – in Polish 'reakcja endotermiczna i egzotermiczna' – 'do' refers to absorbing, 'z' refers to releasing; one student states that exothermic reaction is similar to exotic countries and the fact of energy release is established in this mnemonic device). The difference in the reported examples may be regarded in another aspect. Namely, the teachers seem to give examples that relate to the general use of mnemonic devices, while students give specific examples. Take, for instance, the task of memorizing the symbols of the elements. The teachers would state, that this can be achieved by the use of acronyms or acrostics along the period or group in the periodic table. Whereas students tend to give concretized answers, for example the gold symbol is related to the sound that one makes when one's ear is being pulled by the gold earring (such sound in Polish is denoted by "Au"). Another example would regard memorizing formulas. Teachers indicate that it can be memorized by a short poem, while students find that in order to remember for example Lambert-Beer absorption formula, one should imagine two prisoners (probably Lambert and Beer) sitting in a cell (in Polish prisoner cell is written as 'cela' which corresponds to the formula c•e•l=a). These examples may indicate the fact that teachers are familiar with mnemonics from the theoretical aspect and the practical aspect can be ascribed to students. However this is not the rule, because, for example, Fig. 03 presents a physics teacher way of remembering two specific equations.

Other selected examples relating to the use of rhymes are presented in Fig. 04 students and pupils (asked about the mnemonic devices they know) were also asked to provide the answer to the question regarding educational stage in which exemplified mnemonic device has been acquired. Fig. 04 shows examples given by students who are using these mnemonics since lower or upper secondary school. Students as well as academic teachers were giving examples from higher education level of learning. For instance, the thermodynamic cycle and a sentence – first letter of words correspond to the names of thermodynamic function are presented in Fig. 05.

Gdy zachować chcesz urodę,
wlewaj zawsze kwas na wodę.

When you want to preserve the beauty,
always pour acid to water.

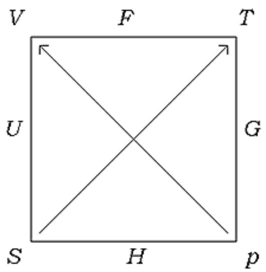
Fenoloftaleina jak malina,
rumieni się jak dziewczyna.

Phenolphthalein is like raspberry
– blushing like a girl.

W I ćwiartce wszystkie są dodatnie, w II tylko sinus,
w III tangens i cotangens, a w IV cosinus.

All Students Take Calculus
or
AllScience Teachers (are) Crazy

Fig. 04. Rhymes as a way to remember chemistry (top two, English translation is given) or mathematic (bottom, English equivalent is given) issues.



Vicekonsul **U**rugwaju **S**tary **H**rabia
Pafnucy **G**ryzł **T**warde **F**istaszki

Vice consul of Uruguay – the old earl
Paphnutius – gnawed hard peanuts

Fig. 05. Guggenheim square and Polish equivalent to the well-known English sentence: Good Physicists Have Studied Under Very Fine Teachers. Polish version relates to other direction in which the thermodynamic square should be read. A free translation of Polish sentence has been proposed.

Pupils preparing for exams (e.g. upper secondary school final exam – Matura) provided very interesting examples, such as the one in Fig. 06. A violet flower (a dark verbena for instance) has to be imagined and the oxidation states of manganese should be organised in descending order ending at the root of lower. A purple flower petals corresponds to the Mn(VII) colour, plant stem (or grass) corresponds to greenish colour of Mn(VI), the colour of Mn(IV) (in the solid form of MnO_2) resembles the ground colour and water transparency corresponds to the colour of Mn(II) in a diluted solution.

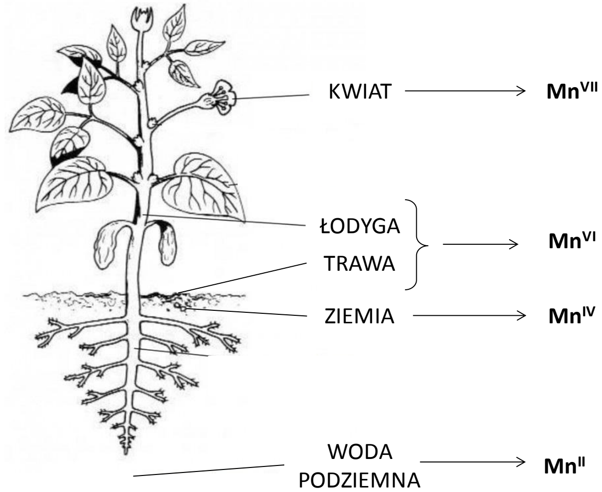


Fig. 06. An upper secondary school student's mnemonic device for remembering the colours of manganese compounds.

A popular example, but acquired in an interesting circumstances, is a way to remember the elements in the second period of periodic table (Fig. 07). Of course, this method may be extended to other periods, as well as groups. The teacher, who gave this example, stated that she acquired such mnemonic from her supervisor during pedagogical practice.

It is well known that medical students need to memorise a tremendous amount of material. One of the examples shows how to remember the bones of the wrist (Fig. 08).

Lidko Beatko Bóg Ciebie Nastał Ocalić Feralny Neapol

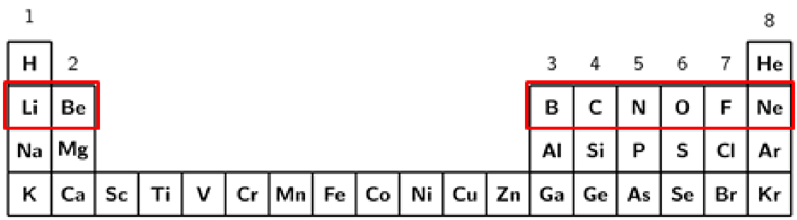


Fig. 07. How to remember the elements in the second period? Given sentence has an equivalent in English: Little Ben Became Charlie's Number One Fighting Nemesis. In the free translation of the given Polish sentence the following can be written: Lydia, Beate, God unleashed you to save the accursed city of Naples.

Fig. 08. Bones of wrist can be easily remembered by a medical student via presented sentence. The English equivalent is known as well: Some Lovers Try Positions That They Can't Handle.

Conclusions and implications

Instances of mnemonic devices usage among students and teachers seem to confirm the interest in this subject even by the fact that although these methods are not familiar with the specific name, they are used. The nature of the use of these methods is different when considering a group of students and teachers. The former are focused on specific application and the latter group is more concerned with the possibility of introducing such methods to students, but both groups supplemented questionnaires with examples. It appears to be necessary to deepen this issue and conduct studies that could evaluate the effectiveness of the use of mnemonic devices in the learning process. Because mnemonic methods are not very popular, more research is needed for a better understanding of the role of mnemonic devices.

Our future plan is concerned on the preparation of a book describing the theoretical approach to the methods of mnemonic devices as well as many specific examples to use in science education. Especially should be emphasised that mnemonic devices, particularly when used in skilful way, may improve quality of life in most aspects of the challenges of today's world.

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HOW TO USE MUSIC DURING THE CHEMISTRY LESSONS

Grzegorz Krzyśko

Introduction

Music has been an effective tool in teaching for many years, mostly the tool "to break up the monotony." The use of original musical pieces existing in the culture or creation of new songs in the classroom with students brings about new opportunities for teaching. By using sample musical pieces in the classroom during the chemistry or science lessons, the teacher creates unique conditions for creative, active and exceptional way of sharing knowledge. The research by A.M. Anteneh indicates that "music-based teaching", with the use of original music, raises motivation and increases the involvement of both students and teachers in the educational process [Anteneh, 2014].

Ronald A. Berck gives 20 reasons why one can use music in the learning process. These are:
- Grabbing students' attention;
- Focusing students' concentration;
- Generating interest in class;
- Creating a sense of anticipation;
- Establishing a positive atmosphere/environment;
- Energizing or relaxing students for learning exercise;
- Drawing on students' imagination;
- Building rapport among students;
- Improving attitudes toward content and learning;
- Building a connection with other students and instructor;
- Increasing memory of content;
- Facilitating the completion of monotonous, repetitive tasks;
- Increasing understanding;
- Fostering creativity;
- Improving performance on tests and other measures;
- Inspiring and motivating students;
- Making learning fun;
- Augmenting celebration of successes;
- Setting an appropriate mood or tone; and
- Decreasing anxiety and tension on scary topics [Berk, 2008].

Howard Gardner, psychologist and author of the "multiple intelligence" theory, defined intelligence as the ability to solve problems. At the same time he distinguished eight types of intelligence which each of us has, and which constitute a kind of trouble shooter. Each of these intelligence may be strong, moderate, or weak. Music is one of the eight identified intelligence types. The use of different forms of music in the classroom increases the possibility of this kind of intelligence and at the same time raises the level of interest in learning. The results showed a significant increase in both creative thinking and motor skills among students using music in the classroom. Research also indicates that creativity and the physical expression of children can be enhanced by the usage of music in the educational process [Anteneh, 2014].

Introducing music to chemistry or science lessons can also increase the involvement of students in the case of difficult issues. These are the potential benefits from the use of music on each stage of a chemical education:
- enhancement of recall,
- reduction of stress,
- content delivery through multiple "channels" or modalities,
- improved homework compliance,
- opportunities to explore content creatively [Crowther, 2012a].

However, previous studies indicate that there is a tendency to use the already existing "science songs" and "music-based lessons" in high school and college-level courses. The songs are not just a tool for rapid memorisation, but also in the process of text analysis, which can also be a cognitively demanding activity. One of the potential obstacles to the use of songs may be a lack of a teachers' conviction to use them during their lessons. Teachers who use music in the chemical education, stress that the song should have a content adjusted to the topic of the lesson and should be easy to remember. As music evokes strong emotions that can improve memory, it is used by students to memorise key concepts, formulas, definitions and biochemical processes [Crowther and Davis, 2013].

Also, the science lessons in secondary school create different possibilities of using musical pieces and songs to present chemical issues. The integration of the natural sciences with various fields of art, creates an opportunity to introduce interdisciplinary topics.

Chemical karaoke

The first attempts to use chemical content in the lyrics appeared in the 60s of the twentieth century and one of the pioneers include: Tom Lehrer ("The Elements"), Flanders and Swanns ("First and Second Law"), Kate and Anna McGarrigle ("NaCl") [Pye, 2004].

There are many examples of the impact of chemistry on contemporary popular music (pop music):
- the names of the bands (Chemical Brothers, Golden Earrin, Iron Maiden, Alchemia)
- album names (Live's "Throwing Copper" [1994], Semisonic's "All About Chemistry" [2001], Manchester's "Chemical weapon" [2008]),
- titles of songs ("Iron Man", "Cocaine", "Lithium", "Sodium Pentothal", "Neon Knights", "Liquid Mercury", "The Chemicals Between Us")
- songs referring to the terms, phenomena, the form associated with the chemistry (Maanam's "Good night, Albert", Golec uOrkiestra's "Chemical waltz") [Golec uOrkiestra, 2002; Maanam, 2011; Pye, 2004].

Teachers can also find valuable examples of songs that were written specifically for educational purposes. For example, the SingAboutScience.org database contains more than 7,000 catalogued songs that can be used in nature of chemistry lessons at different levels of education [Crowther, 2012b].

Cory C. Pye created a new "chemical" lyrics to well-known and popular hits, to sing a capella or with the use of a karaoke machine, along with his students. The song "Billy Jean" [1982] by Michael Jackson received new lyrics about nitrobenzene.

"Nitrobenzene"

It said that her name was nitrobenzene, as it caused a scene,

Six carbons, two oxygens, nitrogen, five hydrogens,

In a plane, delocalized, all around (repeat this line)

She was organic, aromatic, with a functional group,

No alkanes, alkenes or alkynes to be found around here,

Conjugated, nonchiral, with pi-electrons

My prof always tells me, about alkyl halides,

And alcohols, phenols and aldehydes,

Oxidation gives ketones, or carboxylic acids.

Mind your ethers and esters, amines and amides.

Nitrobenzene has no isomers,

It's just a molecule who knows that it only has one,

Second functional group? There is none [Pye, 2004].

Another way of introducing music to chemistry classes is to use the existing culture songs with content related to the specific chemical issues. An example would be the song "Good night, Albert" by Maanam, written by Olga Jackowska, released on the "Wet Cat" album [1985].

"Good night, Albert"

Tick tack . . .

Scientists secret theories

Einstein, Bohr, Roentgen, Curie

Atomic, quantum, poles

Quiet - louder - rays

Hissing neons, blinking windows

I want to sleep . . .

Tick tack . . .

Sodium lights, diodic aura

Radio-active packed

I want to sleep . . .

Triangles, cubes, silver-spheres

Everything spinning, electrified

Good night, Albert!

Good night, Willy!

And if you want

Sleep with Mary

Good night [Maanam, 2011].

This song can be used for chemistry lessons as a repetition of the material on the construction of an atom or radioactivity at secondary school. The recording is available on the Internet and on the "Wet Cat" CD by Maanam. A song gives the possibility to create a test from a particular topic or can be used as an example of infiltration of the chemical content with the culture during the nature lessons.

The lyrics of a song can inspire a teacher to create multiple tasks test. Here are examples of simple questions about the characters that appear in the song and associated with the world of science:

Question: Who is the creator of the theory of relativity?

Answer: Albert Einstein

Question: Who published a paper in which he described his model of the hydrogen atom in 1913?

Answer: Niels Bohr

Question: Who in 1895 discovered a new type of radiation, which is used in medicine?

Answer: Wilhelm Roentgen

Question: Who discovered radium?

Answer: Maria Sklodowska-Curie

Chemical analysis of opera

Not only the songs but also opera pieces can be used during chemistry or wildlife lessons as an example of intertwining of science and art. Making chemical analysis of fragments of operas is an opportunity to broaden the knowledge of the various fields of chemistry [Gulińska & Krzyśko, 2014].

In many operas already analyzed one can find examples of many inorganic and organic compounds, as well as materials that already have a historical significance. In librettos one can find threads where there is a figure associated with the natural sciences, such as pharmacist and chemist. In other cases, chemical substances appear in the form of chemical poisons, and constitute one of the most important elements of the history of drama and opera. J. P. André, a chemist and an opera expert, divided the operas by a type of chemical messages into:
- pharmacy related operas (pharmacists and alchemists stories)
- natural toxins operas (substances of plant and animal origin)
- poison related ancient stories operas (historical or legendary figures),
- arsenic operas [André, 2013].

The twenty-first century witnessed creation of operas in which main characters were Polish chemists. One of them is the "Madame Curie" opera exhibited in 2011 in Paris, as part of the International Year of Chemistry, in the year of the hundredth anniversary of Maria Sklodowska-Curie second Nobel Prize. The work was composed by Elzbieta Sikora. The libretto, in which private and scientific threads intertwine were written by Agata Miklaszewska. One of the characters appearing in the show is an American dancer Loie Fuller. She asks the Nobel Prize winner to give her a sample of radium to be used in her production of "Dance of Radium", staged in 1904, in the United States. The dancer, called "electric Salome," was inspired by the contemporary scientific discoveries. For example, she used the phenomenon of electricity in set design [Gulińska & Krzyśko, 2014].

On 24 October 2013, the premiere of the 40 minute "Breathe Freely" opera by Scottish composer Julian Wagstaff took place. The piece was performed on the day of 300-year anniversary of the establishment of the department of chemistry at the Edinburgh University. The title was borrowed from a book by Professor James Kendall (1889-1978), who was an employee of the Edinburgh University and a specialist in poisonous war gases. This work shows a fragment of the history of Stanisław Hempel (1882-1961), Polish independence activist and a chemist. During World War II, James Kendall made the laboratory available for Hempel who worked for the Polish army [Gulińska & Krzyśko, 2014].

The opera in which there are natural poisons, whose chemical structure and toxicological properties have already been fully understood is "Il Trittico" from 1918, by Giacomo Puccini. The author of the libretto is Giovacchino Forzano, who had knowledge of pharmacognosy, which could have an impact on the content of the libretto. The illustrated story takes place in Italy in the seventeenth century and involves Sister Angelica, who has spent many years in isolation. When the main character learns that her son is dead, she decides to poison herself and for this purpose she prepares a special plant mixture. In the "Amici fiori" aria we can hear what ingredients the Sister used to create the deadly concoction, and these are: oleander, cherry laurel, hemlock and belladonna [Gulińska & Krzyśko, 2014].

Oleander (Nerium oleander) is a plant that produces highly poisonous glycoside called oleandrin. Death follows by cardiac arrest. The plant is common in the southern part of Europe (Fig. 01) [Gulińska & Krzyśko, 2014].

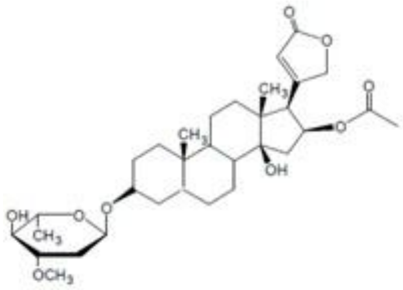

Fig. 01. Oleandrin – chemical structure.

Cherry laurel contains amygdalin, which is a glycoside present also in the seeds of fruit of other plants such as plums, peaches, cherries or almonds (Fig. 02).

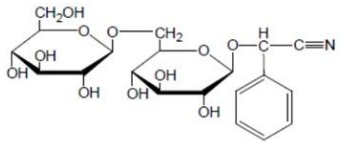

Fig. 02. Amygdalin – chemical structure.

As a result of decomposition of amygdalina in the human body hydrogen cyanide (HCN) is formed, also known as prussic acid. The cyanide ion (CN-) precludes the use of oxygen by the cells and inhibit the process of energy production. Death follows as a result of a drastic reduction in oxygen and decrease of energy. Detoxification consists mainly of reducing the cyanide concentration in the blood. One of the ways of treatment is using hydroxocobalamin, which is a form of vitamin B12, in which the hydroxyl group-OH is replaced by a cyano group -CN- to form cyanocobalamin, which is not a threat to human life and health. This vitamin belongs to organometallic compounds, in the molecule of which ion Co3+ forms a specific bond with the carbon atom of the cyanide ion (Fig. 03). In nature, it is produced by bacteria of the animals digestive system [Gulińska & Krzyśko, 2014].

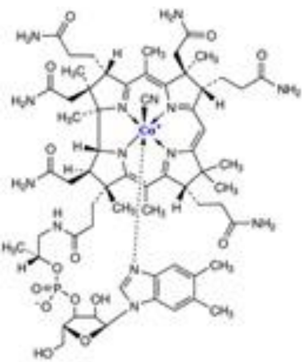

Fig. 03. Cyanocobalamin - chemical structure,

Belladonna is a name of the plant Atropa belladonna, containing atropine and scopolamine (Fig. 04).

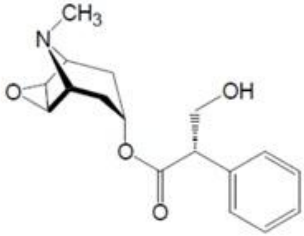

Fig. 04. Scopolamine - chemical structure.

Both alkaloids lead to death due to respiratory arrest. The name belladonna probably comes from the eighteenth century, when women in Venice used the juice of the berries as a means to enlarge their pupils. The Renaissance women's eyes were suppose to shine and make the eyes look more beautiful [Gulińska & Krzyśko, 2014].

Hemlock, Conium maculatum is a highly poisonous plant, mainly due to the presence of two alkaloids: coniine and coniceine (Fig. 05) [Gulińska & Krzyśko, 2014].

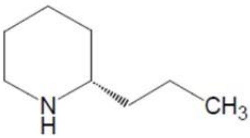

Fig. 05. Coniine - chemical structure.

Hemlock poisoning causes respiratory paralysis and death by asphyxiation. A lethal dose of the plant is around 6-10 g. Poisoning can occur as a result of plant sniffing. The researchers synthesized the molecules of scopolamine with butyl group and received butyl scopolamine. Alkaloid derivative does not damage the central nervous system and can be used as active ingredients in relaxants (e.g. Scopolan) (Fig. 06) [Gulińska & Krzyśko, 2014].

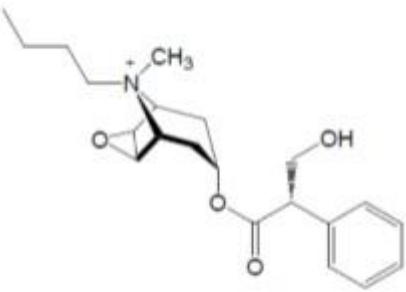

Fig. 06. Butylscopolamine - chemical structure.

The chemical compounds of natural origin contribute to death in the "L'Africaine" opera (" The African woman") by Giacomo Meyerbeer, staged for the first time in 1865. It is a story of the African Queen and a slave - Selika who decides to poison herself by breathing in the scent of Hippomane mancinella tree flowers, because she is unhappily in love with Vasco da Gamma [Gulińska & Krzyśko, 2014].

Mancinella is one of the most toxic and dangerous plants. Its resin can cause skin burns and eye contact can lead to blindness. One of the toxic compounds in Hippomane mancinella is physostigmine (Fig. 07), an alkaloid which in the human body turns into an acetylcholinesterase inhibitor [Gulińska & Krzyśko, 2014].

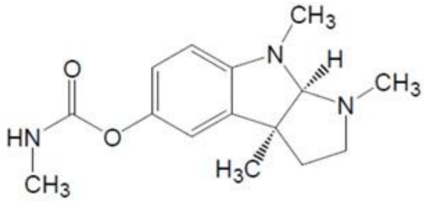

Fig. 07. Physostigmine - chemical structure.

Operas are full of stories about poisoner using arsenic compounds. These stores are based on real events or myths. The most common compound, which served as a means of poisoning opponents and political enemies was oxide of arsenic (III). One of the greatest poisoners using arsenic in medieval Rome was Lucrezia Borgia (1480-1519). In the opera by Donizetti Domenico "Lucrezia Borgia" Lucrezia saves her lover, who had to drink wine poisoned with arsenic given to him by her husband [Gulińska & Krzyśko, 2014].

Arsenic poisoning causes: damage to the stomach, vomiting, bloody diarrhoea, cramps, and cardiac arrest. The treatment involves use of arsenic chelating agents. One such compounds is dimercaprol, which is 2,3-dimercaptopropanol, also known as the British anti-lewisite (BAL - the British ant-Lewisite) (Fig. 08) [Gulińska & Krzyśko, 2014].

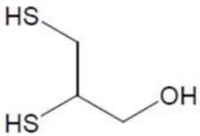

Fig. 08. 2,3-dimercaptopropanol (BAL) - the chemical structure.

This compound was prepared in the course of World War I, as an antidote to poisoning war gas called lewisite. Dimercaprol molecule contains two sulfur atoms, easily combined with arsenic, which makes it easy to remove it from the body. It is also used as a drug for metal poisoning, such as with mercury. Another compound frequently used is the detoxification procedure is 2,3-dimercaptosuccinic acid (DMSA), which as a derivative of BAL is also a chelating agent, a highly soluble in water and can be administered orally (Fig. 09) [Gulińska & Krzyśko, 2014].

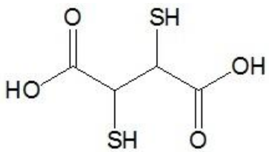

Fig. 09. 2,3-dimercaptosuccinic acid (DMSA) - the chemical structure.

DMSA is a less toxic drug than BAL and may therefore also be used to treat lead poisoned children [Gulińska & Krzyśko, 2014].

The opera was also an inspiration for perfumers creating new scents using fragrant organic compounds. In 1929, Jacques Guerlain created a floral-aldehyde fragrance called "Liu", which was an expression of admiration for one of the heroines of Giacomo Puccini's opera "Turandot Princess". In 1962, Jean-Paul Guerlain produced a perfume called "Chant d'Arome" because of his fascination with music [Gulińska & Krzyśko, 2014].

Musical works were also created by chemists. One of the examples is Alexander Borodin (1833-1887), a chemist and a composer. His doctoral thesis concerned chemical and toxicological properties of arsenic acid and phosphoric acid. His subsequent studies were conducted in the field of organic chemistry (e.g., polymerization and condensation of aldehydes). Borodin composed, among others, symphonies, string quintets and the opera titled "Prince Igor", he was working on for the last 17 years of his life, and which was completed only after his death by Rimsky-Korsakov and Glazunov. "Prince Igor" tells a story of Russia in the twelfth century and the opera is staged to this day in Poland, for example in the Wrocław Opera [Gulińska & Krzyśko, 2014]

Emil Votoček (1872-1950) another composer and chemist who composed more than 70 music works, mostly for piano and orchestra, for example, "Allegretto grazioso" (1932), "Thema con variazioni for Piano and Soprano Voices" (1934), "Violin and Violoncello" (1938), "Serenade for French Horn and String Quartet" (1943). His research focused mainly on the chemistry of saccharides. Votoček also dealt with the analysis of natural products and artificial colors [Gulińska & Krzyśko, 2014].

Many chemical elements were the inspiration for the creators of music. The most frequently cited in the musical works are gold and silver, which symbolize wealth, luxury, power and authority. For example, in the opera of Richard Wagner's "Das Rheingold" a golden ring can give strength and power over the world, but it can also be the cause of misfortune [Gulińska & Krzyśko, 2014].

Conclusions

A piece of music in the chemistry or wildlife lessons is most commonly used as an interesting material for the introduction of new teaching content or reviewing and memorising the material. Appropriately tailored educational songs also encourage students to creative problem solving and test writing. Also, operas can provide a teaching aid. Opera performance is an interesting background to tell the story of chemistry, pharmacy and medicine and a source of knowledge on chemistry, pharmaceutics and toxicology. Teacher and students can seek chemical content and re-read musical works. A contact with opera pieces can also be an inspiration for further exploration of natural clues in various works of art.

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DIDACTICAL GAMES FOR CHEMICAL EDUCATION

Renata Šulcová, Barbora Zákostelná, Marie Reslová

Active teaching techniques in science education in connection with modern electronics belong nowadays to the equipment of an experienced chemistry teacher for every level of education. This article focuses on various aspects of the use of interactive learning, primarily on the position of educational games among methodological resources in science education.

Meaning of didactical games in chemical education

According to the exploration among teachers there was recorded noticeable shift towards using modern technology and resources of education which, together with multimedia teaching aid, can act simultaneously on the human senses. Undoubtedly it leads to better results in science education. The curriculum can be deeper and more permanently accepted, for example in the form of own pupils' "research activities" [Šulcová & Zákostelná, 2012].

Didactical game is a special phenomenon which can serve the developing of skills of students, needed for solving complex tasks and activities. They will be required later by solving their projects and "research activities". This knowledge and skills can be gained through a series of educational and electronic games. These didactical games can engage students into education so intensive that they even encourage such a concentration, which can't be achieved by any other method [Petty, 1996].

The survey [Šulcová & Zákostelná, 2012] confirmed that students can be effectively activated by the appropriate work with electronics and information technologies and therefore they can achieve better work results, greater autonomy and creativity during developing their competences and skills in scientific literacy. There can be developed activation of teaching and learning through the appropriate use of serious games as educational resources by such a method which our current curriculum requires. Students who played educational games achieved repeatedly significantly better test scores than the control group of students who didn´t participate. These experiments confirmed that the suitable motivation and mobilization of students through information technology by taking advantage of modern educational methodology leads to better work, greater autonomy, creativity, and thus can develop information literacy and scientific literacy of students [Zákostelná, 2009]. In addition, certain types of simulation games allow students to perform such experiments as well as those for whom in common schools is usually not sufficient equipment [Petty, 1996] or are not performed at all by the hazard. Some of these experiments are implemented in videos flexible programs for chemistry [www.studiumchemie.cz, 2013].

The next attention is focused on educational games for teaching of chemistry in publications of our or foreign authors and also on development and verification of our own games (table, card and electronic games) which we have created.

Variations of parlour board and electronic games in chemistry

The most of interesting educational games with chemical themes are built on the principle of well-known games: whether desktop board games (Ludo - Keep smiling, Memory Game - pexeso, Bingo, Sports betting and horse racing - Monopoly), or testicular IQ (such as quizzes, puzzle, cross out or crosswords, sudoku, dominoes and error texts) as well as old card games of type quartet [according to Šulcová & Zákostelná 2010, 2012]. All of them are developed in either classic or electronic modification. Other games of recent years are purely electronic, suitable for data projection, tablets or interactive whiteboards. Many of these games are used by teachers to motivate students to test or verify the acquired knowledge of chemistry. From this view we had made research to professional journals as Biology-Chemistry-Geography, SciEd in Czech Republic, or Journal of Chemical Education as well as the websites of faculties of science or pedagogical faculties at the Czech universities.

In following text there are selected examples of chemical games from our own domestic production (The Department of Teaching and Didactics of Chemistry at Faculty of Science of the Charles University in Prague) as well as similar examples of games from foreign authors [summarized review e.g. Russell, 1999], published in the Journal of Chemical Education. Descriptions of games are only short characteristic, but it isn´t possible to play games by them (the references are always quoted). We try to create and disseminate our analogies of card or parlour desk or electronic games with the aim of teaching chemical topics amusingly.

The first here are selected examples of card games, which use different cards or playing plates:

Quartet: Chemical laboratory; Molecular models [Zákostelná, 2012] The cards contain images and names of laboratory equipment, tools and safety and warning symbols - or names, types, formulas and actual shapes of molecules of organic compounds. The game rules are the same as the classical quartet. The Domino game [Horáková, 2012] consists of cards with simple nomenclature and formulas of chemical compounds or Chemists bingo [Burešová, 2011] are games for practising brand elements, formulas and properties of simple compounds.

From foreign ideas of card games published in the Journal of Chemical Education here are selected [by Reslová, 2013]: ChemPoker, ChemOkey [Kavak, 2012] based on the game Scrabble. Element Cycles [Pippins et al., 2011], Families of Chemical Elements [Mariscal, 2012] – students exchange cards to achieve complete element groups; Go Chemistry! [Morris, 2011] – players create compounds from cards of ions attached to each other and identify names; Lipid Puzzle [Büdy, 2012] – players consist cards to form lipids. Where's Ester? [Angelin & Ramström 2010] – players guess the names of compounds from cards, questions are only yes-no.

Second here are reminded games combining elements of chemistry with jogging or fast reactions. Varied range of that games were created by Burešová [2010-2011]: Ticking, Natural trail, Families, Scarf, Relay, Quiz. All of these games are competitions in speed of search, classification and combinatorial skills and physical abilities.

As the third here are examples of board and table games, which use different game-boards (playing field), dice or slot figures and card with questions. All these games are played on a similar principle of "Keep smiling", players must correctly answer the questions on different topics in some fields. We choose next games from our production: Erlenmayer bulb [Zákostelná, 2009], Chemical Marathon, Steroid hose, Saccharid (Chemist) keep smiling!, Mysterious Alkaloids [Šulcová et al., 2004, 2007, 2012, 2013], Chemlife [Burešová, 2011].

From foreign authors we choose: CHeMoVEr [Russell, 1999], Organic Mastery [Mosher et al., 2012], Geometry, polarity and relationships of molecules [Antunes, 2012].

Knowledge competitions consist of a large group of parlour games that can be played individually or between groups of players. We have created: Chemistry, I´m sorry! – a type of game "Europe"; Chemactivities; Humble acid!; Highly toxic; varied memory games (= pexeso): Sweet, Vitamin, Enzyme; Cris-cros saccharides; electronic gamebook Mysterious oil [Šulcová et al., 2007, 2008, 2010, 2011].

Other games – Hess´s points race, Six shots in the box, Four gold (Šmejkal, Šmejkalová 2009) – were created according to TV quizzes, like many others.

Electronic knowledge quizzes are very popular and rapidly expanding form of games motivated by desk games or inspired by well-known TV competitions as memory games (Pexeso), AZ quiz, Jeopardy!, Suitcase or Millionairess (in Czech Republic). Many of the chemical games created usually in electronic form of PowerPoint presentations can be used with diverse content and themes [Šulcová et al., 2007, 2008, 2010], [Zákostelná, 2009, 2012] [Teplá-Roštejnská et al., 2009]: Pyramids 5P [Šulcová et al., 2008], Could you know anything of Chemistry? [Zákostelná, 2009] or The Floret [Horáková, 2012] are types of AZ quizzes. Many types of Chemical Jeopardy!

or Fight with memory! [Zákostelná, 2012] can test chemical knowledge. Other games are: Do you want to be the best? [Šulcová et al., 2008]; Who with whom? (= Millionairess); Show me, what you hide! (= Suitcase)[Zákostelná, 2009). Current hypertext competition as Chemical pentathlon is published on website of Faculty of Science in Prague (www.studiumchemie.cz).

Next games are used to explore and discover science through research method. They can be used for inquiry based science education (IBSE) because they are structured by a way that everyone wins and no one loses, is not necessary to solve who is the winner. Especially there is important the common experience of the game. [Reslová, 2013].

From our resources we have created for example games Walking with Carboxyl; Humble acid!; Hangmann; Connect [Šulcová et al., 2007, 2010, 2012]; Chempuzzle Ikosaedr [Míka, Šulcová et al., 2013].

From foreign authors we can select: Nucleogenesis! [Olbris &Herzfeld, 1999]; Equilibrium Principles [Edmonson & Lewis, 1999], Modeling Dynamic Equilibrium with Coins [Bartholow, 2006], Lego stoichiometry [Witzel 2002], Enzyme Kinetics [Hinckley, 2012]. Some of games use PC, other paper, sugar cubes, colored beans, bobons, Lego bricks, coins and so on, to model the principles and situations. Thereafter players record graphs and derive general conclusions. In games Clip Clues [Fies & Mason, 2008], Guessing the Number of Candies in the Jar {Ryan & Wink, 2012] are determined bonding of elements in molecules and formulas of compounds or particle counts, units (e.g. mol).

As the last point we have created simulation games based on experiential learning: the characteristic feature is that participants can play them on a different reality. Everyone has here a part; it may resemble to observer a theatrical scene. These games give to participants the opportunity to test how they can react in various situations. This type of game is very often used in the learning by experience [Čáp & Mareš, 2001], [Petty, 2006].

The dramatization of chemical processes constitutes Enzyme activity (illustrative experiments) [Šulcová et al., 2006]. The Surprise in the laboratory [Reslová, 2013] is the game what allows students to experience forms of treatment in lab accident. The game Crime Service of Yoknapatawpha [Šulcová et al., 2011] is based on detective investigation with evidence and clues including application of chemical knowledge.

Conclusions and implications

In the article there are shown some selected educational chemical games published by home or foreign authors, as well as some interesting games for education of chemistry. Some of them were created at the Charles University in Prague, Faculty of Science, Department of Teaching and Didactics of Chemistry. Didactical educational games belong to the modern methods for activation of students which can work with student's knowledge and experience. Moreover, games are used in experiential learning, when student gains a new competence through the reflected experiences.

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THE LIFESTYLE OF SECONDARY SCHOOL CHILDREN IN THE LESSER POLAND REGION IN XXI CENTURY WITHIN THE ASPECTS OF PHYSICAL ACTIVITY - PART II: TIME MANAGEMENT

Paulina Zimak, Wioleta Kopek-Putała

Introduction

Physical health and psychological well being of a human are closely related to one another.

Awicenna

Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (WHO, 1946). There is widespread belief says that the move is good for health. Physical activity with proper nutrition are considered basic health determinants for many years. Under the concept of physical activity is commonly understood as activities related to physical activity and movement (sport and the effort of daily activities).

Regular physical activity from an early age has a beneficial effect on our body:
- contributes to the normal development of the physical, mental and social
- helps to prevent disturbances disease (reduced risk of obesity, heart disease, cancer, posture, prevents the development of high blood pressure, strengthens the muscles and bones),
- is a counterweight to a sedentary lifestyle.

From an early generations can see significant changes in your lifestyle. These changes are supported by the development of technology, amenities of civilization, communication means, the era of computerization, which affect a significant reduction in motor activity of society. Looking at the appearance of the young people it can be concluded that the physical activity levels of society, can leave much to be desired. Therefore, the need for a healthy lifestyle, you need to inculcate and develop from an early age.

Issues associated with a healthy lifestyle, are present in the mass media, scientific articles Nodzyńska, Zimak & Kopek-Putała, [2013]; Wojtyła, Biliński, Bojar & Wojtyła, [2011]; Sępowicz-Buczko, [2003]; Dybińska, & Stasik, [2013] and in The basis of the Programme and the curriculum (min Klocki autonomiczne. Koncepcja edukacyjna Szkoły Podstawowej, Gimnazjum i Liceum. Wychowanie fizyczne Zespół Gdańskiej Fundacji Oświatowej pod kierunkiem K. Hall. Gdańska Fundacja Oświatowa.)

The core curriculum of early childhood education in physical education and educational stage is that in the field of health education student should know how important health is proper nutrition and physical activity. On the second stage of education includes: safe participation in physical activity and recreational sports with an understanding of the importance of health:
1) participation in physical activity for the health, recreation and sport;
2) the application of safety rules during physical activity;
3) explore their physical development and physical fitness and practicing healthy behaviors (including the principles of active rest).

In middle school (third stage of education) core curriculum includes: attention to physical fitness, proper development, physical health, psychological and social understanding of the relationship of physical activity to health, in particular:

1) the ability to evaluate their own physical fitness and course of physical development in adolescence;
2) willingness to participate in recreational and sports physical activity and their organizations;
3) understanding of the relationship of physical activity to health;
4) personal and social skills conducive to health and safety (including discussing the health

benefits of making various forms of physical activity in the subsequent periods of human life) and health education.

Student:

1) explains what is health; lists the factors that positively and negatively affect the health and well-being, and identifies those which may be affected;

2) lists and threatening behavior conducive to health and explains what is and what determines choices beneficial to health;

At the fourth stage of education while it is assumed: preparing for physical activity throughout life and to protect and improve the health of their own and others, in particular:

1) awareness of the need of physical activity throughout life;

2) use in everyday life the principles of a healthy lifestyle;

3) acting as a critical consumer (receiver) sport;

4) skills conducive to preventing disease and improving physical, mental and social.

It might seem at such a vast education in physical activity that students should know and properly care for their proper development in terms of physical activity.

The aim of the study was to investigate how school students spend their free time and what is their level of physical activity.

In particular, sought to answer the following questions problem:

1. Are you satisfied with the way you spend your free time? Would you change anything?

2. How long per day do you spend on fresh air?

3. Do you practice any sport?

4. What kind of sport do you play? What discipline is your favourite?

5. How much time do you spend on your computer?

6. What time do you go sleep?

In order to answer the research questions posed above, it was decided to test the following hypotheses:

1. The youth is not satisfied spending their free time, so they would like to change something.

2. Young people spend too little time outdoors.

3. Pupils practice sport insufficiently.

4. Pupils like team sports. Boys like football.

5. Pupils spend so much time per day on computer.

6. Young people go sleep late around midnight.

One could think that with such an omnipresent promotion of a healthy lifestyle, pupils should know its rules and apply them on an everyday basis.

Materials and methods

In order to verify the above hypothesis, a research among 111 pupils aged 11-16, living in Lesser Poland Voivodeship (Cracow, Zakopane and their area) concerning their lifestyle was carried out in two groups: urban and rural. Detailed structure of samples presents Tab. 01.

Tab. 01. The sample description – place of living and sex.

sex	Place of living	
	town (n)	village (n)
woman	18	33
man	11	49

The research included all the aspects of teenagers' lifestyle: eating habits, leisure time activities, hobbies and interest, system of values. This article presents teenagers' lifestyle from the point of view physical activity. In research Internet questionnaire within the options provided by Google Documents was used to collect data. This questionnaire has many advantages such. opportunity to gather information electronically in a fast and convenient way, and automatic transfer of the answers given by respondents to a spreadsheet and create charts and diagrams in the so-called summary of the response options. Analyzes were performed using Statistica, $\alpha = 0.05$. Earlier research [Nodzyńska, Zimak & Kopek-Putała, 2013] showed that groups (rural and urban) differ from one another in terms of the structures of variables, in further analyses the correlation of variables was analysed separately.

Results and discussion

Answers of questions 1-6

Question 1: Free time: Are you satisfied with the way you spend your free time? Would you change anything?

The respondents are satisfied with way of spending their free time [Dybińska, Stasik 2013] except for rural boys. Results are presented in Tab. 2. Further detailed analysis shows that rural boys prefer team sports such as football, maybe in rural areas they do not have adequate facilities so boys are not satisfied. Respondents spend time on: going for a walk, running, meeting with friends, watching TV, using PC, reading and learning and other [Dybińska, Stasik 2013].

Tab. 02. Answers of pupils on question 1.

Group		Number of pupils answers		
		No	Average	Yes
rural	girls	4	2	27
	boys	**19**	6	**24**
urban	girls	1	5	12
	boys	1	2	8

Question 2: How long per day do you spend on fresh air?

The village youth spend more time outside. They spend time mainly with friends. Youth are about 1-3 hours on fresh air per day in both samples. Some additions are observed in urban boys group 1-3 hours and more than 5 hours and in urban girls 1-3 hours and less than 1 hour. 46% of the young people every day or almost every day spend in the fresh air revealed Wojtyla et al., [2011] research.

Question 3: Do you practice any sport?

Approximately half of the respondents in the countryside and in the city practice sports regularly. Boys from city declare sometimes and regular sport practice. The sport activity in both group is on similar level only girls from village are more regularly active than urban (Tab. 03). According to Dybińskiej & Stasik [2013] girls prefer more passive recreation (52%) compared to boys (23%) who prefer physical activity.

Table 3. Answers on question 3.

Group		Number of pupils answers			
		No	No, but I want	Sometimes	Yes, regularly
rural	girls	2	5	7	19
	boys	2	-	23	24
urban	girls	1	3	7	7
	boys	-	-	5	6

Question 4: What kind of sport do you play? What discipline is your favourite?

Rural and urban boys prefer team sports. The same conclusion revealed Dybińska & Stasik [2013] in their article. Rural boys prefer football. The girls form a village and urban prefer individual sports [Dybińska, Stasik 2013]. In the city youth prefer winter sports (Fig. 01).

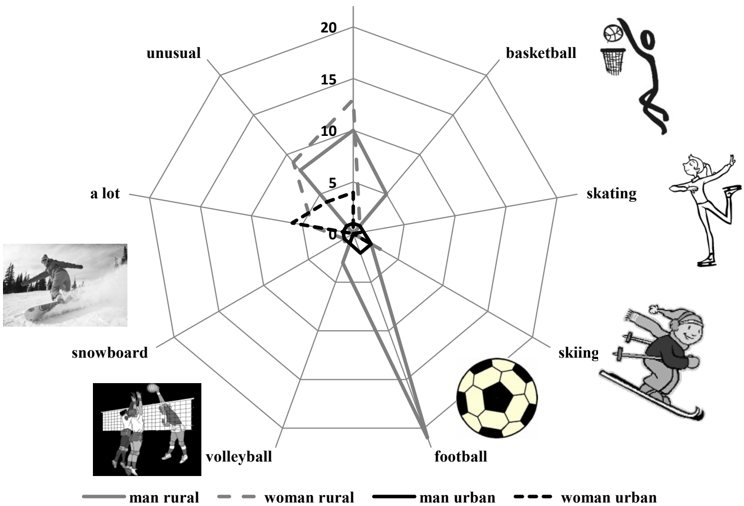

Fig. 01. Students' sports preferences in both groups.

Questions 5. How much time do you spend on your computer?

Pupils spend about 1-2 hours (man rural and urban*, woman urban) and 3-5 hours (woman rural) on PC per day. This last result it is interesting because of girls' lifestyle in village. In group of boys from the city it is observed two maxima (*1-2h & more than 5h). Summarizing pupils spend a lot of time on PC (Fig. 02). It will be worth to describe for what purpose pupils use computer (this results we will present in next article). 60% of youth daily or almost daily spend time in front of the PC and TV [Wojtyla et al., 2011], which confirms the growth of sedentary behavior in adolescents, especially in girls [Garcia et al., 1998; Sallis et al., 2000; Trost et al., 2002 for Wojtyla et al. 2011].

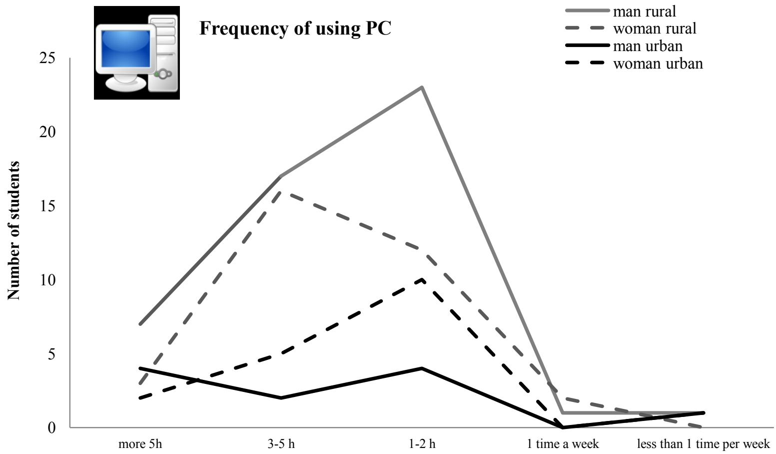

Fig. 02. Computer usage by pupils.

Questions 6. What time do you go sleep?

Research shows that the majority of young people goes to bed every day around 22-24. No boys from town and no girls from village go sleep at 21 o'clock. Most of rural and urban respondents go sleep at 23 o'clock. Generally pupils go to bed quite late for their age (Fig. 03).

Fig. 03. Youth sleeping time.

Statistical analysis

Variables: sex and BMI index were analyzed in compare to questions 1-6 for each group $\chi 2$ test showed statistically significant differences in rural group in category of spending free time and kind of sport which student prefer (Tab. 04). Boys from rural group are half satisfied with spending their free time and they keen on team sports like football. Girls form village prefer individual sports and they are satisfied from way of spending free time.

Tab. 04. Results of testing the hypothesis that features are independent.

Variable: sex [W/M] in rural and urban vs **variables:**	**Pearson's χ^2 MLχ^2 Yates'χ^2 ***	**df**	**p**	**Statistical conclusion**	**φ correlation coefficient; *V Cramer's**	**Sample**
Are you satisfied with the way you spend your free time? Would you change anything?	7.798	1	0.005	features are dependent	0,31	rural
What kind of sport do you play?	21.160	2	0.000	features are dependent	0,534	rural

Explanations: Pearson'sχ^2, ML (Maximum Likelihood) χ^2 – value of test statistics; * Yates'χ^2 (calculated for cross tabulations 2 x 2, when numbers in sub-classes are small, less than 10 (according to some authors – less than 5 – was also applied in the above analysis) df – degrees of freedom; p – test probability. Pearson's correlation coefficient φ is used for a four-fold table, V Cramer's coefficient is used for cross tabulations, in this case *2* x *3*.
COMMENT: By applying the V coefficient we acquire full comparability between cross tabulations sized w x k and the measure φ for fourfold tables (Wołek, 2006).

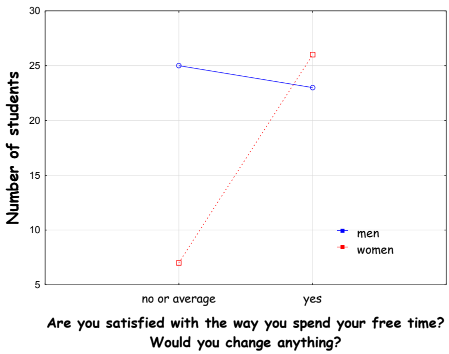

Fig. 4. Diagram of interaction in rural group

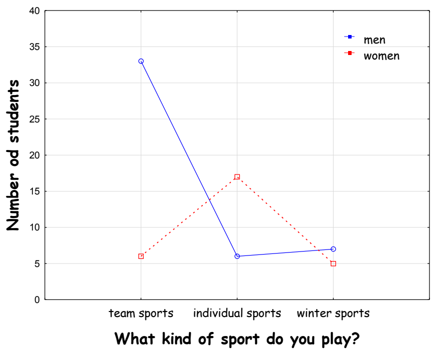

Fig. 5. Diagram of interaction in rural group

solid line - men, dashed line women

Conclusions

The respondents are generally satisfied with their leisure time with exceptions village boys. They prefer team sports like football, maybe in rural areas do not have adequate facilities. Students come quite late to bed. A lot of time they spent on the computer. A sedentary lifestyle and improper eating habits, including easy access to fast food favor the occurrence of overweight and obesity among young people. Only around one third of young people in adolescence takes physical effort to guarantee proper physical development [Brosnahan et al., 2004 for Wojtyla et al., 2011]. This phenomenon entails a number of consequences in an adult life, so physical activity levels of youth, among others, should be recognized. Low levels of physical activity is considered the primary public health problem in developed countries [Wojtyła et al., 2011]. Special attention should be paid to the education of young people to help them to properly shape the awareness of a healthy lifestyle, not only in terms of the proper way of eating, but also in terms of physical activity [Wojtyła et al., 2011]. It is important to talk about physical activity with youth, parents and teachers as well as take concrete practical action in village, town. Preventive care and the impact of physical activity is important for proper development of children.

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Podstawa programowa z komentarzami Tom 5. Edukacja przyrodnicza w szkole podstawowej, gimnazjum i liceum - przyroda, geografia, biologia, chemia, fizyka.

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EDUCATION TRIP TO HRADEC KRÁLOVÉ AS A TEACHING METHOD AT HIGH SCHOOLS

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According to the Decree of the Minister of National Education in Poland (23rd December, 2008) the subject named ”Nature” , which includes: Biology, Physics, Chemistry and Geography, should provide students an interdisciplinary view of the world. The aim of this subject is to strengthen students' scientific attitude towards nature as well as boost their interest in the richness of nature and holistic perception of science. After the course, students are supposed to better comprehend the surrounding nature because the learning process should give them possibilities to formulation of hypotheses and verification of them. Moreover, the knowledge should be based on observations and experiments. (http://www.bc.ore.edu.pl/Content/297/jankun_blaszczak-przyroda.4.pdf)

The project entitled “Education trip to Hradec Králové as a teaching method at high schools” was realized by students of scientific group Lapis Lazuli (Pedagogical University) during one-week scholarship to the University of Hradec Kralove (Czech Republic). The participants were supposed to prepare an interesting route trip of Hradec Králové. The intent of the trip was to touch on various aspects of the nature i.e. Biology, Chemistry, Physics and Geography, Moreover, the students had to check their project through the self-evaluation as well as had to prepare it for teaching purposes e.g. in nature class at the high school. The evaluation results showed that their trip project was highly interesting for high school students as well as it provided a wide range of science information. The plan of the trip includes among others: visiting the church of Holy Spirit, a small hydro power plant and the science museum. (http://www.hradeckralove.org). Here we present eleven stops on the trip, during which there is a possibility to familiarize with renewable energy sources, rare plant or animals species or different types of minerals.

1. The Cathedral of the Holy Spirit

It is a Roman Catholic cathedral which was built in 1307.In has unique font made of tin -. Gutters are decorated with metal figures presenting animals which are half crocodile and half mermaid. Visiting this place may allow to introduce topics connected with metals and their alloys, their properties and uses in various industries.

2. The meteorological device on the market

On the market we can see a special device which measures current temperature, pressure and humidity. Thermometer, anemometer and hygrometer could help us to answer the question: What determines the weather conditions and climate of Hradec Kralove and its vicinity? On the basis of this knowledge we can discuss about the animals and plant and their adaptation to the environment.

3. The South Terrace in Hradec Králové

The third point on the planned route is the South Terrace in Hradec Králové. The ancient fortifications is partly open to the public. There are statues, cascading fountains and bowers. The reconstruction of the south terraces of the town's original medieval fortifications lasted two years and was completed in the autumn of 2011. The reconstruction work was a part of an integrated development plan for the town of Hradec Králové. This is a perfect place to spend pleasant and quiet time in the city center. Our proposed topic to realize is: Organization of the leisure and outdoor recreation.

4. The Special Houses in Hradec Králové

On the market in Hradec Králové we can see some houses with names, which became from names of animals.: The House of the Gold Lion, The house of the White Horse or the House of the Golden Lamb. Watching the architectural splendor one can also refer to the biological topics related to the construction of the mammalian body, differences between mammals, birds, amphibians, reptiles, fishes and insects, their adaptation to life.

5. Žižkovy sady

The Park Žižkovy sady is placed on the north of the old city walls and it is a perfect place for relax during the exploring the center . It was designed on the model of French gardens with neat area planted with flowers and trees. There is also a fountain in the center of the park. At this place students can recognize various forms of the nature protection.

6.Šimkovy sady

Šimkovy sady is the biggest park in the city which has a picturesque landscape. Here you can find ponds which are known from their unique shapes as well as admire diversity of fauna and flora. The residents of the park are wild ducks and the Eurasian Coots

7. The East Bohemian Museum

The seventh point on the planned route is the East Bohemian Museum. It has an exhibition of the natural history collections. There is a presentation of flora and fauna of nearby geographic regions and forms of other continents as well. The Museum carries out many educational activities and it promotes learning through experience. A part of the exhibition is virtual that allows to engage multiple senses of visitors. Teachers and guides together may organize teaching workshops, tailored to the age of the students as well as educational requirements. While exploring the museum it is possible to realize any topic related to the structure and function of plants and animals.

8. Hučák Small Hydroelectric Plant

The tenth point of the trip is the Hučák Small Hydroelectric Plant. Technical monument is situated on the Elbe River. To this day it produces energy for the city. Inside the building there is an information center with models of equipment for the production of renewable energy Here students can improve their knowledge about electricity and rational use of energy.

9. The Jirasek Gardens

Another point of the route is a park: The Jirasek Gardens. The park is located on a triangular area at the confluence of the Elbe and Orlice rivers. It includes, among others the rosarium, the rock garden and the wooden church of St. Nicholas. Many rare species of flowers and deciduous trees grow in the garden. Apart from the rich flora, nutria and ducks can be found there. Direct contact with nature is extremely important in the teaching process. Visiting this diverse ecosystem can be a prelude to the summary of the content of education known by students in the school. Issues to discuss during visiting the park can include such fields of science as zoology, botany or ecology. Our proposed topic to realize is: Interdependent relationships of various organisms in ecosystems.

10. University of Hradec Králové

The twelfth point is the University of Hradec Králové. University of Hradec Králové provides high-quality tertiary education within a large scope of study fields that comprise Social Sciences, Humanities, Educational Studies and Information Technology Studies. There is also a department of Natural Sciences. The Faculty offers, among others, biology, chemistry and physics classes. Experts are also doing academic and commercial research. Our proposed topic to realize is: The role of science teaching – Is it worth to learn natural science?

11. Botanic Garden

In the botanic garden we can admire not only plants which have therapeutic properties but also subtropical and tropical species. Here is a headquarter of the Department of Pharmacy of University of Hradec Kralove where research of natural pharmaceutics are carried out.

Although the educational trip preparation may take a lot of time, such form of the nature classes may be very useful, and above all makes science classes less monotonous. A proposed trip may be held during a school excursion. Students can learn by experience, may put the hypothesis and immediately verify them. This form of education allow to sensitize students to the diverse and multi-faceted nature issues (Grzechynka & all 2005; Nodzyńska, 2005; 2008). As a summary of the tour, students can for example prepare a poster or a short oral presentation for colleagues and teachers. This allows them to share their knowledge, as well as to consolidate and systematize new information.

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‘HOUSEHOLD VS. ENVIRONMENT’ – THE SAILS PROJECT UNIT

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Background

SAILS project - The Strategies for Assessment of Inquiry-based Learning in Science has been funded by EU 7th Framework Programme (2012-2015, www.sails-project.eu). The aim of this project is to support teachers in adopting an inquiry approach in teaching science at second level (students aged 12-18 years) across Europe. “SAILS aims to prepare teachers, not only to be able to teach through Inquiry Based Science methods but also to be confident and competent in the assessment of their students’ learning”(SAILS, 2012). Some resources arising from other international programmes e.g. ESTABLISH FP7 are further developed and enhanced by the SAILS project to create frameworks for the assessment of IBSE skills. One of them was ‘Chemical Care’ prepared by IPN, Kiel developed into “Household vs. Environment” unit. That unit has been tested by Chemistry teachers in secondary schools in Poland and other European countries. Analysis of the changes in proposed materials and new assessment techniques and tools developed by teachers in the piloting phase of the project gave us valuable information about teacher training’s efficacy in that field.

Household vs. Environment - unit for chemistry and environmental education

That unit was dedicated for chemistry and environmental education at lower and upper secondary schools. Ecological consequences of the use of cleaning agents at home (e.g. detergents used to clean textiles) was a problem under consideration for students. Investigation into the topic allows 14 to 18-year-ol students to assess the consequences of everyday decisions in a scientific way. Simple experiments show students what the environmental effects of the incorrect use of i.e. detergents can be. In Poland that topic fits directly to the chemistry curriculum for the first year of upper Secondary school. Two main concepts are covered there, mainly: properties of cleaning and washing agents and ecotoxycology. “This experiment shows very clearly that the action of a chemical – in this case the laundry detergent – does not increase steadily as the concentration increases. Virtually no impairment of plant growth occurs at very low concentrations. In this range, little or no effect is to be expected even if the concentration of a chemical is doubled. As the concentration increases, eventually a point is reached at which the harmful effect suddenly accelerates. Depending on the chemicals and the observed organism, this concentration can vary, and just a small increase in concentration can cause a drastic increase in the effect or damage. When the harmful effect reaches its maximum, it remains virtually constant.” (Parchmann et al, 2007). Two classes (45’ each) and two weeks of homework were suggested to be devoted for that unit.

Household vs. Environment - Suggested Learning Sequence

Lesson No 1

Introduction

The teacher asks students to: List cleaning and washing agents which your families use at home. Based on students pre-knowledge (primary school, or other subjects e.g. biology or earth sciences classes) the teacher proposes a discussion on the possible consequences of the use of chosen cleaning agent on the environment (Assessment tool No 1 – A1). Wastewater from households (for example from the washing machine) is thoroughly cleaned in sewage treatment plants so that it can be discharged into the surface water system. Teacher asks: What would happen if we discharged our wastewater into the environment without subjecting it to any sort of treatment beforehand?

An experiment - The influence of cleaning agent on the growth of plants – group work

Planning. Teacher proposes: Devise an experiment with which you can investigate the effect of cleaning agent on the growth of plants

Discuss with peers what you would like to investigate – ask scientific question, identify and define variables e.g. different concentrations of the laundry detergent

Formulate the hypothesis of impact of investigated factors

Plan an experiment to check your prediction. Decide what you think you will observe or measure and in which way. Write down the plan. (A2)

The unit can be organised either as more open inquiry (various cleaning agents, various species – aquatic, terrestrial plants) or more guided discovery (e.g. influence of the laundry detergent on the growth of garden cress) depends on students' IBSE experiences.

Homework No 1 – recommendations:

Carry out the experiment finding out the impact of the chosen cleaning agent on the environment.

Collect data - record your observations 'How did the plant (i.e. cress) change under the influence of the cleaning agent (e.g. laundry detergent? Analyse the data looking for trends and relationships.

Lesson No 2

Present results of your group work to the whole class in the form of table and graph. Draw appropriate conclusions based on evidences. (A3) Compare your results with results of other groups if possible. Identify any possible sources of inconsistency.

Discuss with your peers, recommendations for the everyday use of cleaning/washing agents in your home. (using e.g. metaplan technique)

Homework No 2

"Cress, is often not suitable for use in such ecological tests, because it reacts relatively insensitively to many chemicals. Instead, organisms such as bacteria, algae, water fleas or small fish are used." [Parchmann, 2007].

Search the Internet or other sources and find out professional ecological tests. Describe two examples – what and which way they test. Quote the Internet sources.(A4)

Household vs. Environment – assessment opportunities

Use of that unit in school practice offers teachers some assessment opportunities i.e. assessment of students' prior knowledge from everyday life and previous educational levels as well as engagement in the discussion, assessment of inquiry plans, assessment of data presentation, assessment of searching-for-information skills. Before the lesson starts the teacher chooses a few learners he/she wants to assess. In the case of written form of group work – planning investigation, collection of data, the teacher collects and assess all group works. Some assessment tools are presented below. Proposed rubrics belong to the group of analytic one [Mertler, 2001].

A1. Assessment of students' prior knowledge from everyday life and previous educational levels as well as engagement in the discussion.

The teacher records the frequency and a level of correctness (full, partial, incomplete, wrong) of selected students' responds (Tab. 01).

Tab. 01. Assessment of students' prior knowledge and engagement in the discussion (worksheet) Student.

Student	Engagement (names of cleaning and washing agents)	Engagement (possible consequences of use the of the chosen cleaning agent on the environment)	Prior knowledge (correctness of an answers)
Name 1			
Name 2			
Name 3			
…			

A2 Assessment of inquiry plans

In that case the rubric can be used to assess a group work (Tab.02). There is a cumulative procedure – it means excellent students should be able to do everything well which characterizes previous groups. Rubric depends on chosen level of IBSE – from guided discovery to open inquiry.

Tab. 02. Assessment of inquiry plans (rubrics).

poor	acceptable	good	excellent
Student is able to…			
propose a cleaning agent and a plant, enumerate 1-2 steps of inquiry	propose a factor/ variable which he/she would like to investigate, enumerate basic steps of inquiry,	formulate hypothesis, enumerate almost all steps of inquiry, consider standardisation of a procedure	propose consistent and completed procedure.

Evaluation of individual contributions to the group work (Tab. 03) can be based on students' self-assessment [Freeman et al, 2006].

Tab. 03. Group work self-assessment sheet.

criteria	Seldom	Sometimes	Often
I contributed as much as I could to group discussions and to the work required.			
I took risks by exploring something new to me.			
I worked cooperatively with other members of my group.			
I listened to others' ideas, respected them, considered their points of view			
I was flexible and willing to follow others but also took initiative when needed			

My two greatest strengths from the list above are: ....

The two skills I need to work on from the list above are: ....

A4 Assessing searching-for-information skills [Sokołowska, 2013]

In order to assess the development of searching-for-information skills, the rubrics can be used (Tab. 04). That tool should be utilized to evaluate the work of a number of students, selected prior to the lesson for this particular assessment.

Tab. 04. Assessing searching-for-information (rubrics).

task	unacceptable	needs improvement	good	excellent
Searching for information	Student is able to...			
	... find out information in 1-2 sources, but does not pay attention to the independence of the sources; s/he does not quote the source	... find out a consistent information in 1-2 sources, but does not pay attention to the independence of the sources; but s/he does not quote the source	... find out a consistent information in at least two substantially different sources, quoting all or almost all sources of information	... find out a consistent information in at least two substantially different sources, summarize it in 3-4 correct sentences, quoting all sources of information

Testing methods

Three Polish teachers piloted the ‘Household vs. Environment’ unit. Their data are collected below (Tab. 05). Teachers piloting the materials answered a list of questions

How did you do this unit?

How has this unit helped to develop inquiry-based learning?

Which aspects of inquiry-based learning has this unit been used to assess?

How was it done?

How confident are you that this unit assessed these aspects of inquiry well?

Successes/problems with this unit in relation to assessment? Evidences (e.g. examples of students’ works and teachers’ assessment)

How would you do this unit differently next time?

All documents underwent qualitative analysis. Teachers statements were analysed, categorized, compared. The most common opinions were identified.

Tab. 05. Characteristic of the pilot phase.

	Teacher 1	Teacher 2	Teacher 3
Level of education	Upper secondary,	Upper secondary, extracurricular classes for students interested in science	Upper secondary, extracurricular classes
assessed skills (proposed in the unit)	Assessed skills reported by teachers (and tools used for that purpose)		
Prior knowledge and engagement in the discussion,	-	-	-
Formulating hypothesis Planning	-	Planning (observation, notes and rubrics)	Planning (observation and rubrics)
data presentation,	data presentation,	presentation of results, (analysis of a report delivered in the form of ppt presentation)	data presentation, (analysis of presentations and students' worksheets)
searching for information	searching for information,	searching for information, (analysis of a report delivered in the form of ppt presentation)	-
group work, cooperation in teams	group work (observation, self-assessment sheet)	- Evaluation of the work of whole groups	-
-	-	drawing conclusions (analysis of presentations)	drawing conclusions (a test)
-	-	-	carrying observations, (observation, self-developed rubric)
remarks	Assessment based on final report prepared by students in the form of ppt presentation		
pupils age	17 years old	16-17 years old	17 years old
size of group	16	10	12
teacher experience in IBSE	First implementation	Rarely use of IBSE	First implementation
pupils' experience in IBSE	First implementation	First implementation	First implementation

Results and discussion

Some teachers assessed some skills proposed in the unit. For example, only one teacher (T1) assessed group work skills. She used students' self-assessment questionnaire and presented evidences showed that, in contrary possible fears, not all the students gave themselves uncritically the highest ratings, but the answers varied. She proposed also her own rubrics for the joint assessment for the entire group (Tab. 06).

Tab. 06. Cooperation skills, group assessment sheet.

	poor	good	excellent
Involvement of the group, cooperation skills (T1)	Lack of involvement in work of all members of the group.	Involvement in work of all the group. Small disagreements, conflicts.	A very good cooperation of all the group. Involvement of all members of the group.

Another teacher (T3) stated in remarks „the students carried out the experiment at home, so it was difficult for me to make a student's self-estimation, to evaluate a group and their cooperation". Those statements can suggest low level of understanding how self assessment questionnaire may be implemented in school practice.

Teachers reported the use of various assessment tools, some of them quite rare in secondary science education in Poland. Among them were observations, notes, analysis of documentations: investigations plans, reports, presentations. Teachers proposed many innovations, changes and refinement of proposed tools. Teachers proposed also their own methods and tools for proposed skills assessment as well as for skills which haven't been mentioned directly in the unit. For example a skill 'formulating hypothesis' in two cases: T3 (Tab. 07) and T1.

Tab. 07. Assessment of formulating hypothesis (rubrics, T3).

Assessed skills (T3)	Criteria			
	Unsatisfactorily 1 point	Properly 2 points	Good 3 points	Perfectly 4 points
Formulating the hypothesis	Student does not formulate hypothesis or formulates it incorrectly; determines target of experiment inaccurately.	Student gives one hypothesis; properly formulates an experiment target, with slight mistakes.	Student gives two hypotheses; asks research question; formulates an experiment target.	Student formulates more than two hypotheses; asks research question; formulates an experiment target.

Another teacher (T1) suggested 0-1 scale "The students form essentially proper research hypothesis referring to a given experiment (0/1)". The question arises why the student has formulated more than one or two hypothesis (T3) and also about a quality of those hypothesis (both cases). For comparison rubrics in that case can look like presented below [Bernard, 2013]

Tab. 08. Assessment of formulating hypothesis [Rubrics, Bernard, 2013].

poor	good	excellent
Student is able to …		
formulate a guess, about what will happen, but it can not explain why.	formulate a guess, about what will happen and explain why. Explanation is given on the basis of his/her own or others life experiences.	formulate a hypothesis, it means a guess scientifically justified.

A test to assess a skill 'drawing conclusion' has been developed by a teacher (T3, Tab. 09)

Tab. 09. Assessment of drawing conclusion skill (a test).

Point out all properly formulated conclusions as a result of the carried out experiment. Mark T if the sentence is true or F if it is false.	
1. Negative influence of chemical agents on cuckoo flower development increases linearly with the increase of concentration.	T/F
2. When the influence effect reaches maximum, then in spite of much more doses it remains almost constant.	T / F
3. In this experiment detergent solutions represent sewages and cuckoo flower represents natural environment.	T / F
4. Ecotoxicology is a science dealing with the influence of toxic substances on ecosystems functioning.	T / F

It is doubtful whether this test actually checks the ability to draw conclusions. In the case of sentence No 1 the "proper" knowledge was rather assessed by the test than declared skill "drawing conclusions" - it could happen that experimental results of some students don't support that particular conclusion described in the point No 1. Sentence No 2 is about observations, sentence No 3 about a design of an experiment and sentence No 4 is just a definition and not a conclusion.

Additional conclusions can be drawn from the analysis of evidences (the evaluation of students' work). In some cases, the need for clarification is visible. For example, some students (T2) stated "Most of detergents used nowadays cannot be decomposed by bacteria – the agents remain in the environment for a long time". They got 'excellent' for 'drawing conclusions' skill but above mentioned statement can not be based on experiments done by students – firstly, is too general and secondly students didn't carry biodegradation tests. It could be a conclusion from literature search.

One teacher (T1) use a semiholistic approach. Assessment was based on an overall judgment of the student work and three different skills, namely: data presentation, searching for information and cooperation skills at the some time using observation and analysis of students multimedia presentations.

Conclusions and implications

From one hand analysis of evaluation sheets and evidences allows us to improve the unit. On the other hand, the new teachers' suggestions clearly show to what (limited) extent they understand new concepts, methods and tools included in the unit, which was presented in the training of project SAILS. It will be taken into account by planning the next winter or summer school for teachers. So, analysis of the changes in proposed materials and new assessment techniques and tools developed by teachers seems to be a good evaluation tool of teacher training's efficacy in that field.

In addition, it should be noted that the pilot teachers conducted ‘Household vs. Environment’ unit only in small groups of students, despite the fact that that topic is a part of compulsory Chemistry curriculum in Poland. This shows that teachers wary of the possibility of inquiry skills evaluation in the average class (30-40 students) during 45 min lessons conducted once a week. It was also expressed by statement “I didn’t expect the homework assessment to have been so time consuming.” (T3). Convincing regular teachers to use more widely formative assessment and rubrics as a tool as well as to evaluate inquiry skills will require a major effort.

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Teaching and Learning Mathematics at all Levels of Education

MATHEMATICS AT THE BEGINNING OF UNIVERSITY STUDIES

Petra Konečná, Věra Ferdiánová

As a result of the implementation of Framework Educational Programmes which, in contrast to the uniform curriculum, offer schools a greater flexibility in processing of compulsory and extending topics, differences in knowledge and skills among secondary-school graduates keep increasing year-on-year even at schools of the same type. It also results in rather non-uniform knowledge in the field of mathematics with the first year university students (for more see [1], [2]). It is the main reason why subjects containing revision of the secondary-school mathematics belong to the obligatory part of the first year at university.

Didactic diagnostics examines results of educational activities. Although it is mostly perceived as a means for classifying students, it particularly serves to optimize the process of educational activities; it provides both teachers and students with the feedback on the results achieved. In terms of a university the diagnostics focuses primarily on the evaluation of the quality of knowledge and skills.

Article introduces form, aims and results of the didactic diagnostics of first-grade students' performance in the cognitive field focusing on the basics of mathematics in the period 2011 – 2013.

The context and purpose of the framework

Mathematics in the first year of university studies is, without any exception, incorporated into the syllabi of all natural science and technical fields of study.

It mainly concerns courses focusing on particular issues that are absolutely essential for other follow-up courses, i.e. dealing in particular with:
- Issue of functions of one or more real variables and differential and integral calculus. Main reason is the necessity of this issue for all technical fields and many scientific fields as well as the fact that this issue has not been obligatory for secondary school mathematics curricula for long time (since 1998/1999).
- Fundamentals of analytical geometry and linear algebra – next area needed for technical, computer science and cartography courses specializing in graphics and design, etc.
- Fundamentals of statistics – a course essential at present even for many humanities disciplines.

Based on the characteristics of a particular field even other mathematical courses are obviously included.

Mathematical fields of study usually start with mathematical analysis, algebra, analytic geometry. All these courses, however, are gone through with deeper theoretical foundations; emphasis is placed on methods of reasoning, mathematical symbolism and general notation and the ability to abstract. It is the reason why the above mentioned courses are supplemented with some other courses which contain the introduction to set theory and logic.

Courses repeating selected parts of the secondary school curriculum in mathematics have always been involved in university study plans. Nevertheless, they have been preferably included in study plans of non-mathematical fields of study. Concerning the applicants of mathematical and technical fields of studies, one would expect a good knowledge of secondary school mathematics, particularly for two reasons:
- majority of such applicants passed the final secondary-school leaving examination in mathematics (it used to be a rather common condition within the admissions procedure);
- knowledge of secondary-school graduates used to be comparable due to a uniform curriculum.

First year of the university study used to follow up directly with the so called higher mathematics.

As a result of the implementation of Framework Educational Programmes which, in contrast to the uniform curriculum, offer schools a greater flexibility in processing of compulsory and extending topics, differences in knowledge and skills among secondary-school graduates keep increasing year-on-year even at schools of the same type. It also results in rather non-uniform knowledge in the field of mathematics with the first year university students (for more [1], [2]). It is the main reason why subjects containing revision of the secondary-school mathematics belong to the obligatory part of the first year at university.

This is also related to another problem and it is a really high fail rate of first-year students.

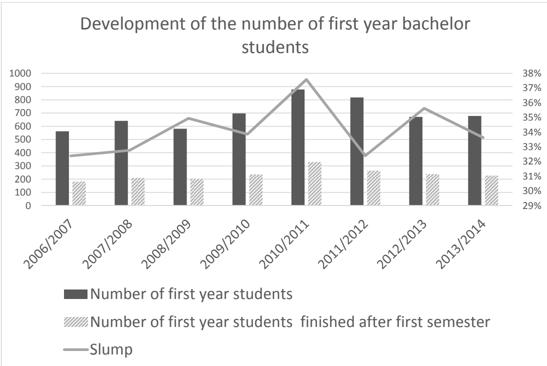

Fig. 01. Development of the number of first year bachelor students.

As for the natural science fields and technical fields in the first year at university, they were always the mathematical courses that mostly contributed to the high fail rate of students. (see Fig. 01) These were, however, the courses containing the „higher mathematics“. At present we may not rely on unified and sufficient knowledge and skills of secondary-school graduates concerning fundamental areas of mathematics and; therefore, without including a „repetitive and levelling“ course results in other subjects would be much worse than they are. (This can actually be deduced even from results of the entrance examinations taken in mathematics – see chapter 3.1)

One solution for increasing the fail rate of the first-year students would be the introduction of compulsory entrance examinations in mathematics. Nevertheless, we encounter the same problem here and it is the non-unified „curricula“ at secondary schools. During entrance examinations such significant differences could not be taken into account. With respect to the persistently low interest of candidates in technical and scientific fields and declining demographic curve, difficult entrance examinations would have negative impact on the total number of students engaged in scientific and technical fields.

These are main reasons why the courses containing repetition of the secondary-school mathematics are compulsorily incorporated into the first year of university studies.

As for the Faculty of Science, University of Ostrava, Czech Republic, the above mentioned function is performed by the subject called Basics of Mathematics. It is currently focused on the following topics of the secondary-school mathematics:
- Algebraic expressions and their transformations,
- Complex numbers,
- Equations and inequalities, systems of equations and matrix algebra basics,
- Exponential and logarithmic functions and equations,
- Trigonometric functions and cyclometric functions and equations,
- Vector algebra basics,
- Analytic geometry of basic figures in plane and space.

It was already introduced in this form in 2006 and was included particularly into study programmes of non-mathematical fields of studies; then, it was optional for mathematical fields. In school year 2010/2011 this subject was included among obligatory subjects even with first mathematical fields.

Subject is supported by an LMS Moodle course, devoted also to students in the full-time form of study, which includes all lectures, examples for practice and interactive materials.

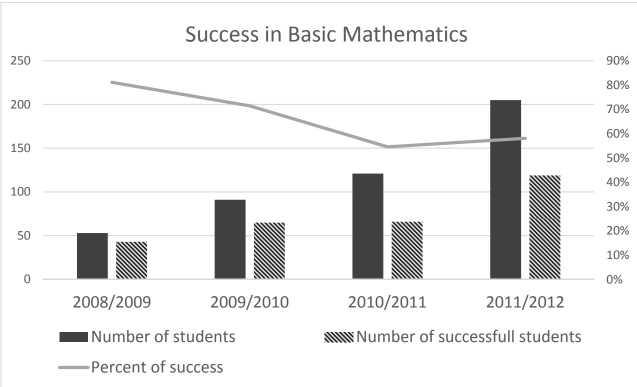

Fig. 02. Success in Basic Mathematics.

Recently, according to consequences of the curricular reform, we have observed a slump of success in this subject (Fig. 02). So we had to react.

Methods

Didactic diagnostics examines results of educational activities. Although it is mostly perceived as a means for classifying students, it particularly serves to optimize the process of educational activities; it provides both teachers and students with the feedback on the results achieved. In terms of a university the diagnostics focuses primarily on the evaluation of the quality of knowledge and skills; it means it focuses on the cognitive field. Thus, at this stage of school education it has three basic functions – to provide feedback, to control and to classify.

Respecting the university environment and the type of a subject, a didactic test in its most common form – the written form – was chosen as a diagnostic method to evaluate performance of students. According to the characteristics of a test performance we chose a level test; it means we measure the level of students' knowledge and skills achieved. The time limit was determined so that all students had enough time to complete the tasks.

When evaluating students' performances we focused mainly on the requirement of unity and its long-term duration, i.e. we were interested not only in an immediate state but also in the development of students' knowledge and skills in particular fields of mathematics monitored. It is the reason why a combination of an entry test where we were finding out the entry level of the knowledge concerning particular subject-matter, and ongoing (formative) tests used to obtain the feedback on current level of mastering the study curriculum was used. Nevertheless, these tests also aimed at evaluating students.

According to the type of preparation of all the above mentioned tests there were originally non-standardized tests, i.e. informal, prepared by teachers. With respect to the fact that these tests are tried out on a sufficient sample of students in the course of years, rules are determined for evaluating, and they are also used for measuring and comparing levels of students in particular grades at school; they may currently be considered quazi-standardized.

Entry test was polythematic; ongoing tests were – with some exceptions – monothematic. Unlike the entry test the ongoing tests contained open extended tasks only; the entry test contained closed tasks as well. Classification was carried out with regard to university regulations based on the percentage of correct answers.

Results

Results of the entry test – year-on-year comparison

Although the subject called Basics of Mathematics was included into compulsory subjects for all mathematics study fields only in the academic year 2012/2013, majority of students of mathematics study fields chose this subject and included it among their compulsory optional subjects even in the previous two years. Structure of respondents, thus, did not actually change that much in the monitored period of time. Major part of respondents is represented by students specializing in informatics, precisely 56 – 62% out of the total number. The reason for that is a several times higher interest among applicants in these fields of study; it belongs among the most massive ones at the Faculty of Science of the University of Ostrava. Two-subject bachelor study programmes combined with mathematics and one-subject bachelor study programmes of mathematics are represented similarly in both years, each in the range 18 – 21%. Other study fields are represented by units of students.

At the beginning of the semester students are offered the option to use the entry test in mathematics within the subject Basics of Mathematics; it is a didactic test in the time span of 60 minutes. If the test is passed with 75%, they are granted the credit. Using this test enables us to find out the level of knowledge and skills of students. This is the way how we obtain the feedback at the beginning and we can focus our further educational process on more problematic issues.

Structure of questions and tasks of the entry test and representation of thematic units is as follows:

	Number of tasks	Number of points %
Algebra	7	34%
Mathematical Analysis	6	28%
Geometry	6	25%
Others	4	13%

Specifically there were tasks where students solved the following issues:

1. Course of a function

2a. Logarithmic equation

2b. Trigonometric equation

3. Analytic geometry

4. Converting complex numbers to trigonometric form

5. Identifying a function from a picture

6. Absolute value inequalities

7. Equation with a parameter

8. Theoretical question, what are / are not equivalent transformations

9. Progression

10. Vector algebra: Vector product

T. Theoretical questions specializing in concepts, terminology and foundations of secondary-school mathematics

Structure of the test was as follows:

Tasks no. 1 – 4 were open extended tasks. It was required to solve the task, including specifying the procedure.

Tasks no. 5 – 7 and 9 were closed tasks of the polytomic type with one correct answer. Correct answer could be found using calculation.

Tasks no. 8, 10 – 22 were closed of the polytomic type with one correct answer again. These questions focused on monitoring the level of knowledge concerning basic terminology used in mathematics; in graph results of questions 10 – 22 are collectively indicated by the symbol T.

Students were introduced with instructions for completing the didactic test and its evaluation in advance. Evaluation of tasks was perceived comprehensively. In case a student used correct procedure, but there appeared a numerical mistake, he obtained a certain number of points. Questions with closed answer were classified dichotomously. Total evaluation of the didactic test was dichotomous – classified as passed / failed. During the educational process the tasks which were causing problems to students were pointed out in order to improve knowledge and eliminate errors.

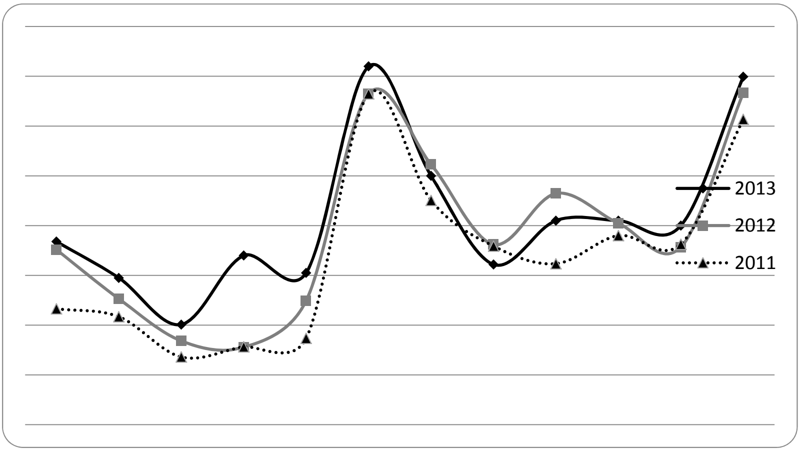

Fig. 03. Degree of success with individual questions concerning the Entry test in mathematics in years 2011 – 2013.

Fig. 03 shows degree of success with individual tasks and questions in years 2011 – 2013. Students' results did not differ a lot in those three years, only with a few exceptions. The easiest task was to make decision based on a picture whether it is the graph of a function (task no. 5). The most difficult task (no. 2b) was to solve the trigonometric equation. Students were not able to apply basic knowledge and trigonometric theorems, nor were they able to use knowledge in transforming algebraic expressions. The most common error with this task was in finding the angle given the functional value of a trigonometric function. Significant differences were observed with task no. 3 which focused on analytic geometry. A big change of the year 2013 was caused by the fact that we reacted to current trend. Majority of secondary schools in Moravian-Silesian Region included analytic geometry in space among extending themes instead of compulsory ones. Therefore, we modified and reformulated that task in order to deal with the analytic geometry in plane. The worst results out of all closed questions were achieved in the task concerning an equation with a parameter. Although it was a closed question where the correct result could be determined by a gradual substitution in offered answers and, thus, one could avoid calculation as such, students made mistakes very often. In total students succeeded in closed questions by 10% more. Reason for higher success can be seen in the fact that even though a student did not know the answer and only guessed, there was a 25% chance to be successful even without the knowledge of the subject-matter.

Didactic analysis of ongoing tests – year 2012

Six ongoing tests were created within the didactic diagnostics of the subject called Basics of Mathematics; these tests included the following fields:

1st test: Simplifying an algebraic expression. Transformation of a complex number into algebraic form. Calculation of power of a complex number and its absolute value. Conversion of a complex number from algebraic form to trigonometric form.

2nd test: Calculation of inequalities with absolute value. Calculation of an irrational equation. Calculation of a system of linear equations.

3th test: Analysis of a function. Solving an exponential equation. Solving a logarithmic equation.

4th test: Drawing a trigonometric graph, determining the range of values. Calculation of a trigonometric equation (2 tasks).

5th test: Calculation of a vector product of two vectors. Determining the deviation of two vectors. Determining the mutual position of lines in a plane.

6th test: Determining the general equation of a plane. Determining the mutual position of a line and plane / two planes / two lines in space (2 tasks).

Except for the first and third test all tests were monothematic. The first and third tests contained two themes of the secondary-school curriculum.

Students were taking the tests every 14 days. They were allowed one second attempt for four out of six tests. It was possible to obtain 20 points as maximum in each test. 50% of total points as minimum were necessary in order to pass the test.

We monitored the students' results achieved[1] and focused on the following figures:

- number of students successful at number of students successful at their first attempt,

- number of students successful at the retake test,

- average number of points achieved by students successful at their first attempt,

- average number of points achieved by students successful at the retake test,

- total number of successful students,

- percentage of students successful at the retake test out of the total number of successful students.

[1]Students who successfully passed the entry test (it means they did not need to take the above mentioned ongoing tests) and students who quitted their studies at the beginning of the semester, i.e. they failed to appear even at one of the ongoing tests, were excluded from the monitored group.

	1st test	2nd test	3rd test	4th test	5th test	6th test
Number of students successful at the first attempt	46	81	69	74	82	81
Number of students successful at the retake test	40	11	21	11	6	5
Average number of points of successful students - 1st attempt	15.0	15.5	15.0	16.0	18.0	18.5
Average number of points of successful students - retake test	16.0	15.0	16.5	16.0	19.5	17.5
Total number of successful students	86	92	90	85	88	86
Percentage of students successful at the retake test out of the total number of successful students	47%	12%	23%	13%	7%	6%

Percentage of totally successful students in individual ongoing tests did not differ a lot; it ranged from 75% - 81% of students; considering absolute numbers, it means the difference of 7 students. Nevertheless, we face surprising results when considering the degree of success in the first test and then retake tests of individual tests. At the beginning – when taking the first test – percentage of successful students who passed it at their first attempt and percentage of students successful after taking their retake test is almost the same. Number of those who successfully pass the test at their first attempt is significantly increasing with further tests. It is particularly surprising with regard to the fact that last tests included trigonometry and analytic geometry, which are generally perceived as more complex than simple algebraic transformations (used for work with complex numbers as well) or solving equations and inequalities.

There are two fundamental reasons for such differences in results. The first obvious reason is the students' need for longer time for the adaptation to both the environment and style of studying at a university. Style of teaching and evaluation is new for them and they need some time to get used to and to adapt to new conditions.

As already mentioned above, the first and third tests were not monothematic. According to our opinion, this is the second reason for higher percentage of students who are successful only after retake tests particularly with the mentioned tests.

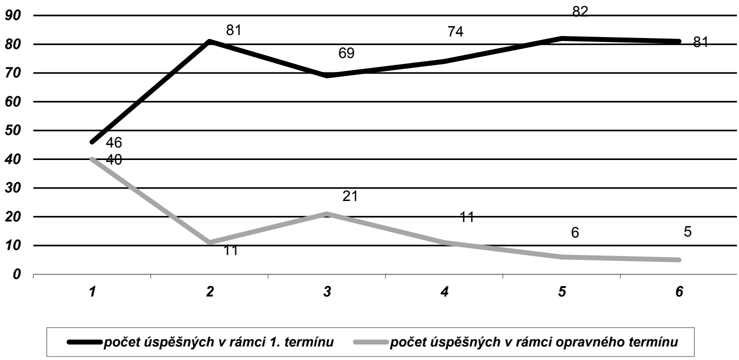

Fig. 04. Number of students successful at test.

Didactic analysis of ongoing tests – year 2013

Within the didactic diagnosis of the Fundamentals of Mathematics course in 2013 only four ongoing tests were carried out with regard to the necessary organizational changes; however, these tests covered all spheres in the same way as it was in 2012.

1st test: Simplifying an algebraic expression. Transformation of a complex number into algebraic form. Calculation of power of a complex number and its absolute value. Conversion of a complex number from algebraic form to trigonometric form. Calculation of inequalities with absolute value. Calculation of an irrational equation.

2nd test: Calculation of a system of linear equations. Analysis of a function.

3th test: Solving an exponential equation. Solving a logarithmic equation. Drawing a trigonometric graph, determining the range of values. Calculation of a trigonometric equation.

4th test: Determining the general equation of a plane. Determining the mutual position of a line and plane / two planes / two lines in space.

With the exception of the fourth test all the tests were polythematic.

Students were taking the tests regularly once in 3 weeks. They were allowed to retake two tests out of the total four ones once more. They could obtain 25 points as maximum in each test and the minimum was to obtain more than 50% of points.

We monitored the reached results of students in the same structure as in 2012.

	1st test	2st test	3st test	4st test
Number of students successful at the first attempt	49	71	59	69
Number of students successful at the retake test	26	4	15	3
Average number of points of successful students - 1st attempt	13.0	19.5	17.0	19.5
Average number of points of successful students - retake test	16.0	16.5	18.0	18.5
Total number of successful students	75	75	74	72
Percentage of students successful at the retake test out of the total number of successful students	85%	85%	84%	82%

The share of overall successful students was approximately in balance and ranked from 81% to 85%; in absolute numbers it is a difference of 3 students. The worst results were achieved within the first date when taking the first test. In further tests the success rate of the first attempt is increasing. A steep rise is noticed with the second test when 95% of students mastered it for their first attempt.

High failure rate right in the first test is owed particularly to two factors. The first of them is the test content that includes algebraic expressions, absolute value inequality, irrational equations and also complex numbers. Expressions and equations represent a standard secondary-school curriculum; however, the topic of complex numbers has not been included in the School Educational Programme at many secondary schools. Second factor is obviously the fact that students are not sufficiently adapted to the university environment, to the style of teaching; in that time they do not make use of the opportunity of consultations yet although they have this opportunity from the beginning of the semester.

High success rate within the first attempt of the test containing tasks of solving a system of linear equations and analysis of a function is expectable as it represents a standard secondary-school curriculum which is paid sufficient attention.

Content of the third test is both more demanding and more extensive. Therefore, a slight decrease in the success rate is expectable. This test also revealed a major problem that has been monitored on a long-term basis – students have a problem to interconnect the already acquired knowledge and skills and implement them to other types of tasks. Describing particularly this test the most difficult part for students was not the procedure of solving a particular equation type but the most errors were caused during the modification of algebraic expressions while there were only minimum of such errors in the first test.

Reason for the following slight increase in the success rate of the first attempt with the fourth test is found in the fact that it concerns a monothematic test containing parts of the curriculum from the last year of a secondary school.

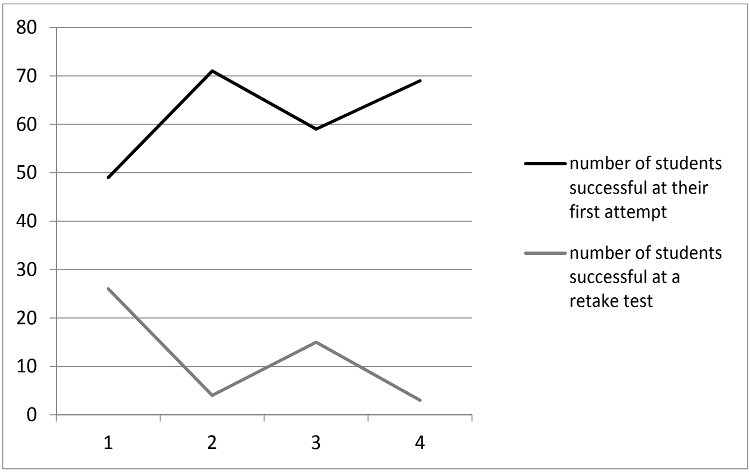

Fig. 05. Number of students successful at test.

Conclusions and implications

In the last three years students' results in the entry test differed only minimally. Yet, by introducing the ongoing tests, we managed to significantly increase the success rate of students in the subject called the Basics of Mathematics. Rate of successful students in 2011 was 58 %; after introducing the evaluation by means of ongoing tests the rate of success increased to 71% in 2013.

From the above stated results it is impossible to come to the conclusion that it is a sustainable growing trend. We rather assume that the boundary of the success rate of around 80% is a notional maximum that could be reached by our hard work (success before 2008, see Fig. 02) and we will try to maintain this level in coming years.

Success rate in subjects 2011 - 2013

Success rate in subjects 2011 - 2013	credit granted	failed to appear	unsuccessful students	Students in total
2011	58%	24%	18%	205
2012	67%	24%	9%	148
2013	71%	17%	12%	138

Results concerning the points achieved by successful students within the first date and the retake date in 2012 corresponded mutually. As for the year 2013 results oscillated particularly in the first two tests. Yet we still believe that based on the results it cannot be deduced that successful students who passed the retake tests reach worse results automatically. Option of a retake test is thus an appropriate motivation for increasing the level of skills and knowledge of students after their first failure.

In addition, based on the analysis of ongoing tests results, in 2012 we came to two more conclusions, which was confirmed in 2013:

First-grade students need time to adapt to new conditions at a university including the style of both teaching and evaluation of the educational process. It is, therefore, worth considering whether it is appropriate for didactic diagnostics to use one-time entry and output tests in first semesters at a university as it is widely applied.

Students are used particularly to monothematic diagnostic methods from their secondary schools. University teachers should, therefore, gradually proceed from monothematic methods of evaluation to polythematic methods. One-step change in this respect greatly increases rate of failures with students in particular subjects.

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MATHEMATICS AND NATURAL SCIENCE SUBJECTS' TEACHER COLLABORATION: NEEDS, LIMITS AND POSSIBILITIES

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Introduction

Natural science subjects and mathematics' teacher collaboration is very important in the latter years and especially in the future. Isolated natural science and mathematics' knowledge conveyance becomes ineffective. Various projects have been started being implemented on an international level, devoted to natural science education development, in general. E.g., since 01 01 2013, Europe Union 7th common programme (FP7/2013-2017) project „Mascil"(engl. Mathematics and science for life) has been started accomplishing. The aim of the project is to encourage broader use of inquiry-based science teaching in primary and secondary schools. Besides, there is a wish to closer relate mathematics and natural science teaching with the working world (http://ims.mii.lt/mascil/).

It is obvious, that natural science mathematical and digital literacy education experiences great challenges. This is determined by various society life changes, first of all, rapid development of technologies, their variety. In the political documents of European Union, a conception was established, that literacy, mathematics, natural science and technology skills are the basis of further learning and employment possibilities and social involvement.

Different sphere teacher collaboration is also understood as qualitatively new approach of teachers' professional development. Teachers' professional development through teachers' collaboration has been reported to be effective for the improvement of schools' performance and students' learning outcomes in all curriculum subjects [Kafyulilo, 2013], besides, cross-grade, cross-disciplinary nature of the collaboration has been revealed [Nelson Holmlund, Slavit, 2007]. Various researches show, that natural science subjects and mathematics' teacher collaboration can be an effective strategy improving students' achievements. Such collaboration strategy should also be applied preparing future teachers. It is obvious, that strong interdisciplinary connections is a challenging task for teachers and teacher educators [Frykholm, Glasson, 2005]. The carried out research showed, that inquiry-based teaching can be successfully developed adjusting collaboration [Magee, Flessner, 2012]. In the USA, in the latter years, a special attention is also given to natural science subjects and mathematics' teacher collaboration. It is accentuated, that it is important to renew teaching standards, to carry out mathematics teaching content selection, in order to guarantee effective integration [Schwols, Miller, 2012]. Collaboration should not be treated as simplified educational activity, extensive teaching/learning method. The essential thing is to find deep relations of both disciplines (spheres) – mathematics and natural science education. Research studies show, that a proper way to understand these important relations is showing two disciplines' connection through illustrating both their concepts interconnectivity in the process of collection, analysis, and data display [Roth McDuffie, Morrison, 2008]. On the other hand, it is obvious, that collaboration (on a practical level, it is quite often implemented teaching together – co teaching) is a complicated matter. Researchers acknowledge that co teaching at the secondary level in science and mathematics can create unique challenges [Dieker, Rodriguez, 2013]. Various co teaching types and integration ways of this approach exist.

Thus, on the one hand, both in Lithuania, and on an international level, decreasing participation in mathematics, science and technology / engineering is observed. On the other hand, competencies in these disciplines are increasingly important for scientific and mathematical competencies in the workplace and for full participation in contemporary society. Such a controversial situation makes us search for its formation reasons, and also find effective ways for changing the mentioned situation using educational means.

The project MaT²SMc is implemented in the frame of EU Lifelong Learning Programme.

The main idea of the project is to find a way to increase students' motivation to learn the key subjects mathematics and science. From one side, mathematics teachers should understand that there is a meaningful and realistic context to use mathematics. From the other side, science teachers should understand that the mathematics competences are required for more effective science teaching and learning. In such a context the collaboration of science and mathematics teachers is very relevant. Collaboration of mathematics and natural science teachers should be expanded, for this purpose, it is necessary to create all necessary conditions and provide didactic support [Lamanauskas, Šlekienė, Ragulienė, 2014]. On a practical-didactic level, it is important to analyze natural science and mathematics teachers' didactic needs, to understand the factors limiting and encouraging/supporting collaboration. Therefore, the main aim of this research is to analyze natural science subjects and mathematics' teacher collaboration experience, the factors supporting and developing collaboration, to evaluate the possible positive influence on students' achievements and to present suitable recommendations.

Methodology of Research

The presented research was carried out implementing a project "MaT²SMc". The research is qualitative. A survey version - Focus group interview was chosen for the research. The researchers think that the discussion going on in groups can disclose the opinions and attitudes which the respondents wouldn't tell in an individual interview (so - called group effect works here). Target group – math and science teachers. Three Focus groups were formed. The first group comprised 12 chemistry teachers from different schools in Lithuania. Discussion in the first Focus group took place in Siauliai university Natural science education research centre. The second Focus discussion took place in Bubiai basic school. Science and math teachers (10) participated in the discussion. The last Focus discussion took place in Siauliai "Romuvos" Progymnasium. Also, science and math teachers participated in group discussion (8). So, in total 30 teachers took part in the research.

The research was carried out under the leadership of a moderator. The discussion procedure was fixated by an assistant moderator. Discussions in each group went on for one hour. Focus group research was carried out using traditional qualitative methods. Data analysis was based on Krueger & Casey [2000] methodology. The researchers applied structural analysis method for data analysis.

Results of Research

Table 01 shows mathematics and natural science subjects' teacher collaboration limiting factors.

It has been stated by the research (the results are presented in Tab. 01), that Mathematics and natural science teachers‘ collaboration on integration purposes at school is limited by five main factors divided into smaller sub-factors. The first of them reveals that *teachers collaborate among each other only at a useful time for them and only when usefulness is discerned from both sides of applicants*. It has been found out, that pedagogues are inclined to collaborate only when it is necessary for them and when it is inevitable – e.g., it is necessary to teach a subject, which is especially related to Mathematics and pedagogues know, that namely using integration method it will be possible to effectively realise the subject‘s revelation and mastering aims in the lessons. It is also stated, that teachers accentuate limitation of revision possibilities, i.e., very often integration is chosen because learning concrete topics, the knowledge of which will be necessary in other subjects, revision is impossible, because the topics are arranged in different semesters of the programme and it happens, also in different classes. In these cases, seeking the pupils‘ deeper knowledge, teachers integrate their subject topic with the topic of the Mathematics subject and achieve the aims – pupils better memorize information and relate it not only with Mathematics, but also with a concrete integrated subject, remembering that knowledge and using it in similar topics in later classes.

Tab. 01. Mathematics and natural science subjects' teacher collaboration limiting factors.

Category	**Subcategory**	**Statements**
Usefulness of teacher collaboration	*Teachers collaborate according to their need*	As much as we need, we directly collaborate with our Mathematics teachers. We question, ask to remind the pupils during the lesson. We communicate.
	Teachers can rarely teach additionally the subjects, that have already been taught	Sometimes Mathematics teachers do not want to go back and explain. They are pressed by the programme as well.
Individual teachers‘ work	*Subject teachers are not inclined to collaborate among each other*	If one subject teacher went to another subject teacher – will there be a result. Only a waste of time of the lesson. Collaboration – two teachers in one lesson - NO
	Teachers doubt in two teachers‘ work effectiveness in one lesson	Joint lessons with a few teachers - scarcely good... Would that help.
	The time of the lesson is saved	It is a pity to give your lesson to another teacher.
The effectiveness of integrated lessons	*Integrated lesson is named as „playful“*	Nothing else, but games from that lesson. Playful lessons will not educate children‘s competences. They accept this as a game – they say – we played during Maths.
	Integration is called as a temporary matter	This is only a temporary matter
Waste of resources	*Teachers have to prepare additionally*	There is no positive result, only trouble to prepare. Preparation for such a lesson takes a lot of time. It limits – it is complicated to prepare, to think over for all parts to match, can‘t fit in the time available. Very often it isn‘t possible to make such lessons, because they require more time and human resources.
	Teachers have to use their financial resources	School administration make you arrange integrated lessons, but they do not pay for that, and you have to prepare additionally for them, you have to buy school supplies.
	It is difficult to plan and model	It is difficult to plan and we have our programmes which need to be implemented.
School influence on collaboration	*In city schools teachers work with new classes every year.*	In city schools it is very difficult to work with children because they always come to a new teacher – teaching goes in spiral and everything repeats in a higher level, therefore in smaller schools teachers have parallel classes. Then teachers make less effort, because children don‘t have the basis.
	City schools lack necessary infrastructure	In city schools the children impaired, because there is not enough of rooms, the number of schoolchildren restricts, because you can‘t go deep into everyone‘s knowledge.

The second cause limiting integration is *teacher inclination to work individually*. Some pedagogues perceive integration as meeting of two teachers in the lesson and common work – and that limits them, because conditions are not created for both pedagogues to completely combine their working style, specific features, applied methods, therefore sometimes one can‘t manage in the time available. The teachers don‘t completely agree with the idea, that both pedagogues are necessary for integration, it would be much simpler for one teacher to match the knowledge of the other subject or to arrange a complete theme integration not at the time of the lesson, but in the project based or after school activity. In senior forms every teacher is trying to give the knowledge of his subject to the pupils and to form necessary skills within its limits, therefore strictly follows the lesson plan, which is always made according to education programmes – pedagogues want to manage to teach planned themes. This determines the teacher‘s conscious choice to work individually, because it is very little foreseen for much freer, more creative and unplanned activity of the lessons in education plans and only that subject pedagogue takes responsibility for education results in a concrete subject. Thus, teachers save lesson time and avoid collaboration with the other field specialists.

Some teachers doubt in effectiveness of integrated lessons. Sharing their opinions, pedagogues accentuated, that sometimes the pupils name integrated lessons as not serious, playful ones and this is not pleasant for the teachers and they don‘t think that in educational sense it is valuable in „serious“ subjects. The information has to be conveyed gradually and thoughtfully in Natural science and Mathematics lessons, but playful elements are not necessary and even sometimes more harmful than useful. On this basis, teachers avoid integrated lessons in order the pupils wouldn‘t call them playful, but evaluate them as a complicated and necessary thing. Some teachers name integration as a temporary matter, which does not create real added value in education, therefore it is not necessary to waste energy and resources for such things.

The fourth reason – *teachers do not want to waste resources during the integrated lesson* and preparing for it. As integrated Mathematics and any other natural science subject‘s theme integration is a compound two teachers‘ creative ability realization part, having to reveal itself only in concrete conditions, the majority of teachers avoid collaboration, because the mentioned process and its result occupies a lot of time: it is necessary to think of a concrete theme, to select examples, to think of a procedure of the lesson, to coordinate vision and action sequence in your educational process with another teacher and also to coordinate with the school administration about lesson joining and auditorium. The teachers also claim, that integration, if you want it to be effective, requires additional financial resources, which the school does not allot, as usual. The teachers themselves have to buy school supplies. In addition to all disturbance, it is said, that the teachers have to possess perfect planning competencies and the ability to model even difficult situations existing in reality and this is more difficult when more than one teacher participates in the education process because the responsibility is not shared equally.

The fifth reason is exceptionally characteristic to the teachers working in big schools, most frequently in cities. The number of schoolchildren is big in them and pedagogues work with parallel classes, therefore they don‘t have any need to organize integration – because they don‘t have the necessity to observe how their pupil will apply the knowledge obtained during the lessons in higher classes i.e., pedagogues cannot see their subject knowledge application continuation. Whilst in small schools mathematics and natural science teachers‘ collaboration is closer, because the pedagogue teaches pupils every subject from the fifth to the tenth form, and if in earlier forms the pupils didn‘t form necessary skills, in the senior forms they will experience learning difficulties and this again will limit activity effectiveness of the teacher himself. On that ground it is stated, that small school teachers are more interested to integrate their subject themes, because pupil knowledge and skill formation sequence is necessary for them, without leaving „unlearnt“ elements, which will be used in future. City teachers experience limitation from the point of view of infrastructure as well – there is lack of auditoriums, because they are always full and even overcrowded, there is lack of free spaces.

Table 02 shows mathematics and natural science subjects' teacher collaboration forms and ways and their demand.

Tab. 02. Mathematics and natural science subjects' teacher collaboration forms and ways and their demand.

Category	Subcategory	Statements
Available means and forms applied for integration	*Teachers apply various additional literature*	We have literature, which is usually useful, if there is willingness.
	Teachers use natural / historical objects	We use up natural historical objects – we don‘t need methodological devices.
Selection of collaboration forms and ways	*Teachers define education forms and ways in discussions*	We don‘t need to have concrete methodological devices, because we discuss and coordinate a lot things ourselves. There would be a demand to combine biology with physics – we talk things over. In physics – the break of light – we combine Mathematics there in order the children would get a better effect.
	Teachers base on experience, applying ways and forms	We have the materials, but we still coordinate with our practice.
Specific features of applied devices (concreteness and newness)	*Teachers would like to have concrete devices*	It would be very good to have methodological devices, because it would save me a lot of time. You would come to a concrete site and would choose concrete ideas – this would make your work easier.
	Teachers would like to have concrete textbooks	In Maths textbook there could be tasks from Biology practical side and in Biology - tasks from Maths.
	Teachers would like to have concrete tasks	It would be good to have differentiated tasks, algorithms... Maybe, separate themes e.g.,: metals – everything about them (chemistry, physics, biology) and with mathematics. Scale. Proportion calculator. Unit.

During integration Maths and natural science teachers apply various collaboration forms and methods (Tab. 02). Most frequently they use the objects, which are available – that is different literature, natural and historical objects. The purpose of the latter is not educational; however, they are namely used for that purpose – e.g., trees, manuscripts and other. Teachers claim, that a lot of devices and methods are created in the process of collaboration i.e., discussing with colleagues and preparing for a concrete theme. During discussion pedagogues decide what form they will apply, how it needs to be realized. The use of any integration method and an instrument or device making it meaningful is the result of teacher‘s experience – the more has pedagogue tried integration methods, the easier and quicker he will apply methods in other activities.

However, the teachers state that they are short of devices, which they could use, wishing to integrate natural science and maths themes in common activities. Pedagogues name, that they would like concrete devices, which would be arranged on desirable themes; also they wish textbooks on integration thematic – especially with examples and tasks.

Table 03 shows mathematics and natural science subject integration demand from the point of view of children's age periods.

Tab. 03. Mathematics and natural science subject integration demand from the point of view of children's age periods.

Category	Subcategory	Statements
Integration demand in the primary learning stage	*In primary school*	Probably for general school
	In early childhood	I suppose that at that moment, when they start learning complicated things, it would be much easier for them like this.
	In senior forms the subjects are detailed	Senior forms have to be taught separately.
	Senior children are more independent	In the 9th-10th forms children do a lot themselves. In senior forms children start to understand themselves where they need to use maths or physics knowledge – the teacher constantly reminds, when and what the child has to recall.

According to pedagogues (Tab. 03), integration is more necessary in the primary learning stage – in primary school, in early childhood. This is based on the fact, that in senior forms the pupils, as the teachers notice, are much more independent, they control information better, are able to find it themselves. Besides, in senior forms, the pupils learn much deeper, go deeper to details and simply there is no time left for integration – the learners themselves have to synthesize the information obtained from different subjects and to relate it independently.

Table 04 shows mathematics and natural science subject integration use in the education process.

Tab. 04. Mathematics and natural science subject integration use in the education process.

Category	Subcategory	Statements
Activation of cognitive processes	*Integration helps the pupils to more easily perceive*	Understand better, recall the content itself – remember with details what they did and how and what is the use.
	In senior forms integration helps to revise knowledge	Until the time they come to another class, the children forget what they learnt about that subject in other subjects.
School subject content systemization	*Children remember systemic information*	Children integrate knowledge, therefore better remember. This forms a foundation for the teachers to make efforts as well, because it is certainly very favourable to work in future. During geography they count and do not have the slightest understanding what they count, zero use. And when they count during biology, they see reality and conformity with it – understand at once, where they need mathematics and how they can use it. They write equation, but do not understand, what they need it for – here it is based more on mathematics , e.g., what is of this, that they learn triangle and so on, what are negative numbers for – pluses and minuses – they measure temperature and everything becomes clear. We turn everything to reality – percentage, e.g., introduce how to buy a thing with a few dozens of discount.
	Pupils do not relate different subject knowledge	It is children's psychological problem, that physics chemistry, biology are separate subjects for them. But they should see all this as one. We live with these ideas. Gather in purposeful groups, because we see big gaps in children's knowledge of different subjects.

Category	Subcategory	Statements
Development of children‘s transferring abilities and different competencies	*Children‘s abilities reveal*	In this context the other children‘s abilities come to light. They reveal themselves – they are not scared. You get surprised.
	Children form transferring competencies	It is not enough for them to know, it is necessary that they formed other competencies, presented, found themselves i.e., were critical enough and thinking.
	Integration guarantees wider competence formation	Integration is necessary – the pupils cannot draw graphic, interpret data, proportions and so on.
	Children become more open and free for education	It seems they don‘t have any complexes.
Learning motivation strengthening	*Children become more active in the lessons*	It depends on children‘s abilities – if the children in class are more of a passive temperament, then we need more integrated lessons, because their thinking level discloses slower and in the later classes they form certain abilities harder. The lesson for children is livelier. We teach children what is the easiest, they don‘t want to think, therefore we need to make them active.
	It is very interesting for children	It is interesting for everybody, we can‘t say where more, because reality is much more interesting – when they see examples, then it is actually more interesting for them. Maybe it is possible without integration – but is is not interesting – neither for teachers nor for pupils, because it is better one integrated lesson than three dry ones.
Mathematics integration suitability and universality	*Mathematics can be integrated in all subjects*	So, we can use mathematics everywhere. Lots of choices. In any concrete theme – we can‘t tell – the most important thing, to combine the programmes, then it is easier. And this depends a lot on teacher‘s creativity. Mathematics explains, and the other subjects teach to solve and apply. And when we explain in the same way, it is very clear for children then. Diagrams – geography – state areas – mathematics – it is a rather dry science, so, the teacher doesn‘t have to think, because in integrated lessons everything is combined – ideas are taken from the other subjects. There are millions of ideas always. They count average temperature in geography in earlier forms and in mathematics lessons they learn it in later forms. In this case, programmes themselves provoke combining.
	It is useful to integrate mathematics in project based activities	Sometimes it is possible to make project works – e.g., by smoking I kill myself. However, this limits, because teachers are not paid for this, therefore we cannot invest a lot of efforts and time. We have integrated after school events – teams of children.

Mathematics and natural science integration‘s usefulness is discerned by 5 aspects (Tab. 04). The first of them reveals, that the mentioned subject integration activates cognitive processes – helps the pupils to easier perceive complicated phenomena, processes, their result; helps to recall information and to keep it in long-term memory, which is especially useful in the time of revising or learning similar topics in other subjects; analogically – integral lesson, going on for pupils is more interesting, therefore they concentrate more and in the process are more active than usually.

The second integration usefulness aspect – *more systemic and wholly information content* *understanding*. Teachers claim, that it is easier for pupils to recall that information, which was taught entirely and systemically, not only as a separate and detailed description element. Pedagogues notice educational success problems – because of too big information amount, present day pupils cannot or do not want to relate information from different subjects, therefore their available knowledge is non-exhaustive and scattered, especially, if they do not learn, but only passively take part in the lessons. In respondent opinion, integration helps to overcome the mentioned problem.

The teachers also accentuate, that *integration helps to train transferring abilities and different other competencies*, which the pupils, having acquired at school, will be able to apply in real life and behind the school boundaries. The pupils, in the learning process, when mathematics is integrated into other subjects, want to learn much more – they *become more motivated* and in the lessons feel freer. The consequence of this always is braver questioning, interest and trying not traditional behaviour models, especially, if the teachers use integral methods. Pedagogues claim, that during integration one can apply various creative methods, during which the pupils themselves carry out experiments, projects, present them and even take part in competitions. The last aspect which the teachers accentuated is *mathematics, as a subject, suitability to integrate with the other subjects*. One can choose and apply various forms and various methods, because mathematics knowledge is applied in many places.

Table 05 shows integration variety improvement spheres.

Tab.05. Integration variety improvement spheres.

Category	Subcategory	Statements
Subject content improvement	*Subject content has to be integral*	Artificial integration will be of no use, it should be natural integration, not that the separate teachers ran one to another, but that the content was combined in the subject itself. To coordinate the content (degrees, fractions...).
	Subject themes do not match between themselves	Mathematics is mostly not coordinated with natural sciences in time. A lot of things are taught in lower classes, and when we need, they are forgotten. Some things in mathematics are taught significantly later. (Vectors, sin. cos. and so on.).
Teaching/ learning programme development and coordination	*Integrality has to be foreseen in programmes*	Mathematics and natural science programmes should be combined, at least in the sense of time and theme. We teach not according to the textbook, but according to the programme, therefore, first of all to combine the programmes. Common programmes are necessary, combined in time, e.g., 11th form pupils cannot draw graphics. They were taught this in mathematics in the 9th form. I have to make revision myself. Sometimes I ask mathematics teachers to remind the pupils. It is necessary, in order to make the teacher integrate certain themes during the programmes.
	Programmes are too wide, there is no possibility to integrate subjects	Our programmes are very wide, we don‘t manage to teach them, if they were integrated, would it be better. The course has to be taught – it is not foreseen in the programmes. Then it is necessary to foresee reserve lessons, so that e.g., it would be possible to devote more lessons for such innovations, integrated and other. The programmes have to be actually changed.

Respondents claim, that there are various spheres, which might be improved (Tab. 05). Three main spheres and secondary ones supplementing them have been fixed by scientific analysis method. The first of them is *subject content*, that has to be improved, which shows, that subject content itself should be more integral, because now it is sometimes especially difficult for the teachers to coordinate the themes in parallel classes, in order they could make an integrated lesson. The teachers state, that very often subject themes do not match among themselves.

Also, in teacher opinion, *teaching programmes* should be improved. Because, namely, in the teaching programmes it is decided what topics the teachers have to pay more attention to, which - less and according to this, they plan their lesson time. Majority of teachers work not according to the textbook, but according to the teaching programmes, therefore, it is very important, that integration themes were clearly foreseen in them. Integration would also be easier if the ways and/or methods were pointed in the programmes, which could be referred to, or if it was accentuated by a request form – then it would be a priority for the teachers. Some teachers complain, that in the teaching programmes it is required to teach the content too wide, therefore, even for programme fulfilment it is not enough of time, not speaking about integration possibility realization in the education process.

Conclusions and Implications

For the teacher, and even more for the student, it is not easy to perceive all tremendous amount of obtained knowledge, skills, to find relations between allied knowledge, abilities and to combine all of them into a unified system. The systematization of obtained knowledge, the formation of abilities are complicated processes. For the formation of physics, chemistry, biology and mathematics knowledge systems, it is important, that the knowledge, obtained at a certain learning stage, was consolidated interrelating it with each other. Favourable conditions are formed for that: generalising, revising certain elements from natural science subjects and mathematics and using them in a concrete lesson, carrying out integrated tasks and other coaching activities. Therefore, it is purposeful to carry out exhaustive natural science subjects and mathematics‘ interdisciplinary integration research studies, the results of which one can use to improve separate subjects‘ teaching practice.

Generalizing focus groups’ discussions, one can claim, that:

- integration helps to train transferring abilities and different other competencies;
- teaching programmes should be improved;
- during integration Maths and natural science teachers apply various collaboration forms and methods;
- mathematics, as a subject, is suitable to integrate with the other subjects.

Note

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Teaching and Learning Physics at all Levels of Education

HOW STUDENTS STUDY PHYSICAL TEXT WITH ILLUSTRATION – THE EYE TRACKING STUDY

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Eye Tracking

What is The Eye Tracking method

Our eyes are the bridge that connects us with our surroundings. Through the eyes we perceive our surroundings and draw information from it. Our vision has one interesting feature, namely the ability to perceive only a few percent area of observing reality in a given moment. Our brain is equipped with a system that determines the most important things for us in a given moment as well as our intentions [http://www.eyegaze.com/what-is-eye-tracking/].

The scientists have taken an interest in the findings about the point at which people fix their eyes. This information tells a lot about the observers' preferences (applied in advertising), the subliminal reactions and emotions (psychology and medicine) and also the process of learning (education). All these fields use the eye tracking method. The eye tracking method has developed from the personal observation by researcher through the difficult and irritating devices placed on the observer's head to modern methods which do not limit the observer's body at all. In some advanced experiments the tools are even placed distantly, so the subject does not even notice them. A device monitoring the eye movements is called the Eye tracker.

What is examined by the Eye tracker

Eye tracker follows the movements of the human eyes showing the involuntary decisions of the subject on the point at which they aim their gaze, so it monitors a human behaviour in the perception of certain object. „Recently eye tracking is becoming a popular method in the context of the usability research. With the help of an Eye tracker the users pupils and their position on a screen are tracked and thus provide detailed data about the users visual attention on user interface elements. It can be used as a valuable source of information about users behaviour" [Manhartsberger &Zellhofer, 2005].

This device not only monitors the movement of eyes, but also records the sequence of points noticed by the subject as well as the length of time spent looking at a particular place. „Ocular movements are divided into fixations and saccades. Fixations appear, when the eye gaze pauses in a certain position - normally lasting between a quarter to a half of a second. Most information from the eye is made available during a fixation. The main goal of a fixation is to identify the fixated object. Saccades are the jumps of the gaze between fixations" [Manhartsberger &Zellhofer, 2005].

Similar studies and their results

Existing similarly oriented studies have dealt with the types of procedures chosen by the tested people to understand the mathematical text while solving the problems [Lindström et al., 2009].

Department of Physics at the Pedagogical University in Cracow under the guidance of prof. Błasiak conducted an experiment in July of 2012 that was aimed at finding strategies students choose in order to solve various difficult physical tasks [Błasiak et al., 2013].

In this experiment there was also examined where students focus their gaze while choosing the responses as well as which answers they subsequently select. In a well-known article the Finnish researchers [Hannus &Hyöna, 1999] observed the division of attention of primary school children between text and illustrations; the studied material was from the field of biology. All these studies have somehow monitored the perception of the text in relation to the images. We decided to focus more specifically on the use of illustrations, namely comic book illustrations in difficult educational texts of physics. We wondered if the images do not distract students from the text excessively and if they contribute to the proper understanding of the subject matter.

In our project we focused on the perception of illustrated text and verification of its effectiveness in practice. We presumed that if we divide a group of students with the same level of knowledge into two groups, one provided with the illustrated text and the other with the simple text of the same content but without illustration just with some simple schemes, the results of these two groups will be totally different. It is necessary to point out that the topic of Compton effect, explained in the text, was completely unknown for both groups.

Research Methods

For the purpose of this test we used the device iView X ™ Hi-Speed by the company SMI SensoMotoric Instruments [http://www.smivision.com/en/gaze-and-eye-tracking-systems/products/iview-x-hi-speed.html].

The sample

Testing was attended by the 26 secondary school students (VII. Liceum Ogólnokształcące im. Zofii Nałkowskiej in Cracow), from this group we had to exclude three students due to wearing the contact lenses and glasses with reflective coating. In these three cases it was not possible to calibrate the device properly. The final sample consisted of 18 boys and 5 girls. These unexpected complications meant that we had to divide the students into groups unevenly. The first group consisted of 13 students and the second group of only 10 students. All the students were from the class which had excellent results in physics, so they could be regarded as the high ability students.

Course of testing

The monitored sample was randomly divided into two groups. After the device had been calibrated, the first group saw the study material on the computer screen. The topic of the material was the Compton effect, a part of quantum physics. This thematic section had been unknown to all students before. Group No 1 studied the material which included a comic explaining the essence of physical action, a simple scheme, and the text divided into two columns. At the beginning, each student was asked to study the material and only then he/she signalled to start the test. The time that student spent studying the material was not limited. After studying the material, a simple test with three questions followed. It was a multiple choice test with three possible answers. The student was supposed to tick the correct answer and enounce it aloud for control. However, the results of one student from the first group had to be rejected as the girl was wearing the contact lenses and the device was not able to monitor her angle of view precisely.

The second group did exactly the same as the first one, though the study material was different. It was a copy of the website of AGH University in Cracow, in which the Compton effect was explained [http://home.agh.edu.pl/~konkurs/1999/4/compton.htm]. Material included two schemes and text written vertically across the whole width of the screen. The task of the second group was selfsame, so after studying the material, students were supposed to answer the same questions as the first group students. From the second group we had to exclude two students who were wearing glasses with a reflective coating as this hindered the device from monitoring their eyes.

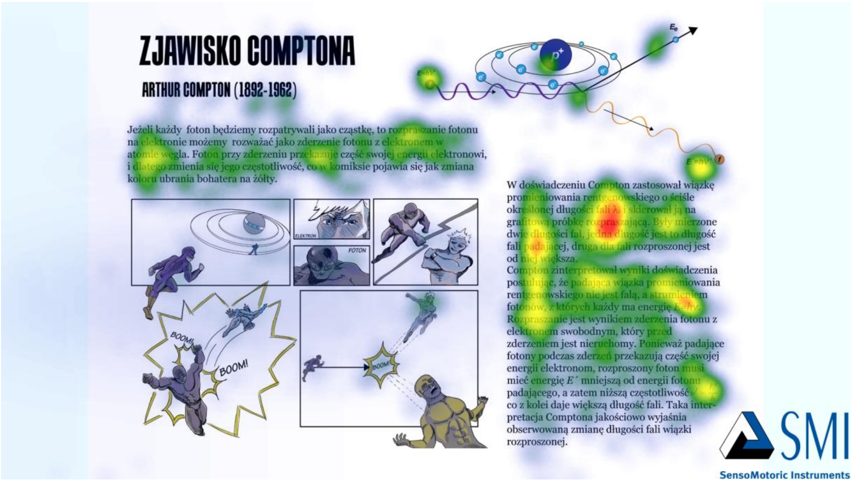
Results

The differences between the groups:

test results

The first two figures show the heat maps of all students from the first and the second group. The colour range from blue to red shows the intensity of concentrating on certain parts of the picture. Prior to the testing, a concern if the illustrations do not unnecessarily distract students from the important parts of the text arose; however, this concern was not confirmed, quite the contrary, the testing proved that the first group focused on the essential parts.

Group no. 1

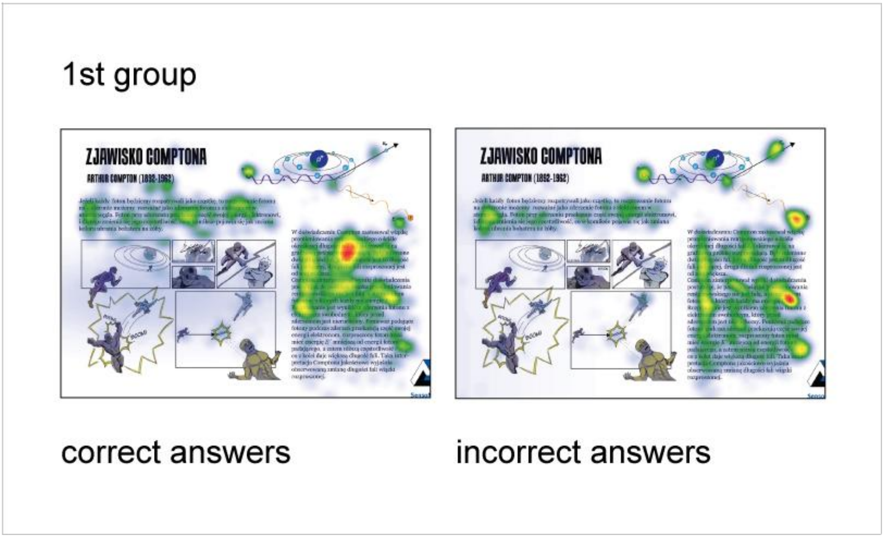


On the other hand, the second group just read through the material and paid special attention only to formulas which they probably considered to be the most important. An interesting fact was that the students paid only a little attention to the title and some of them did not read it at all. This fact also appeared in the first group.

Group no. 2

correct/incorrect answers in the subsequent test

After studying the material, three simple questions with three possible answers appeared on the screen successively and the students were expected to choose the correct answers. We have chosen two students from the first tested group. The first of them answered all three questions correctly and the second one answered at least one question incorrectly. Their heat maps, areas of focusing their gaze, are shown below. It is obvious that the first student focused on the illustration more than the second student.



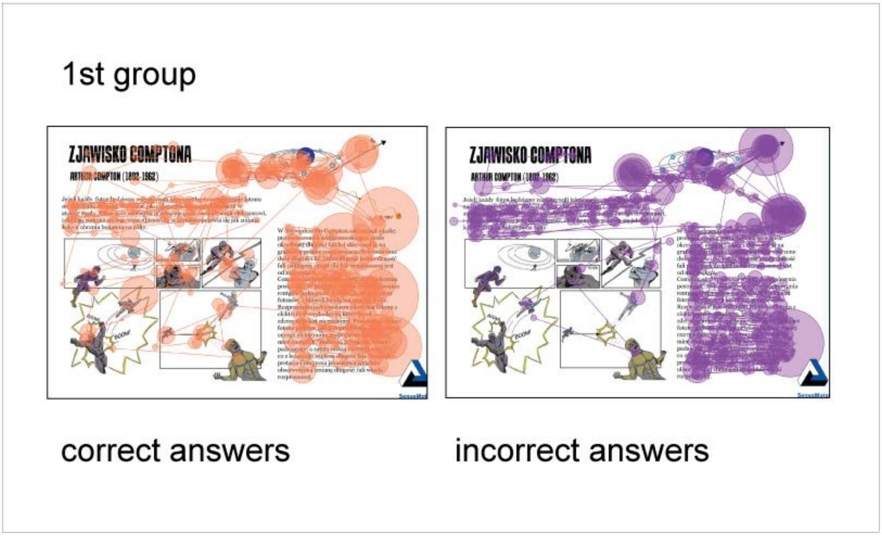
time

Each student had as much time as they needed to study the material and to complete the test. The students themselves signalled to turn the page. Without informing the students, we measured the time of studying the material. After averaging the times, we found out that the student from the first group was studying the material for 118 seconds on average and the student from the second group needed an average of 149 seconds, which is, considering the short duration of testing, a significant difference.

From both tested groups we have randomly selected the so-called Scan Path which shows how a certain student proceeded in studying the material. Circles represent the points on which student focused his/her gaze and the lines connect these points according to the sequence of jumps between the points. The bigger the circle is, the longer the student gazed at a section. This happens particularly in case of difficult or new expressions. The term “correct answers” refers to a student who answered all questions correctly, “incorrect answers” refers to a student who had at least one incorrect answer.

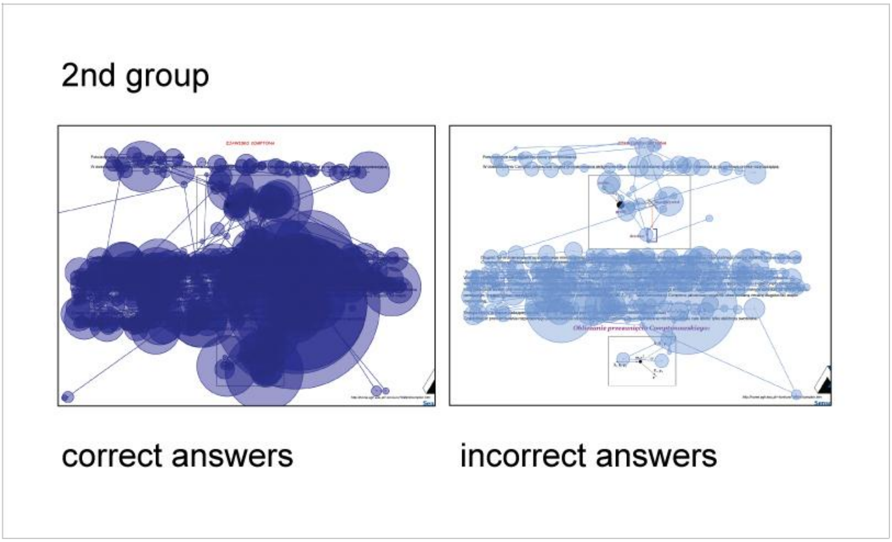
Group no. 1 – correct/incorrect answers (Scan Path)

In the first group the objects of concentration were almost identical, only the first student clearly linked illustrations and the scheme and looked for the connections between them.



Group no. 2 – correct/incorrect answers (Scan Path)

In the second group, only one student answered all three questions correctly; however, the Scan Path shows that he needed a lot of time and concentration for proper understanding and memorization. He spent 287 seconds studying the material, which was the longest time of all. Interestingly, he even did not look at the title.



Conclusion

We have learnt that
- students working with an illustrated text managed to study it in a shorter time
- they were able to divide their attention properly between text and images
- illustrations did not unnecessarily distract their attention from the essential parts of the text
- successfulness of the first group in the test was about 36% higher than successfulness of the second group

	N° of participants	Men	Women	Correct	Incorrect	Average time [s]
1st group	13	10	3	6	7	118,004
2nd group	10	8	2	1	9	149,234

Our study brings a proposal on a visual solution for difficult physical texts with an abstract and often hard to understand content. In such texts it is important to divide a difficult text into several parts and use illustrations and also link the text with a functional and clear schemes. This study proved the efficacy of such text composition compared with random text layout using only the simplified schemes.

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RESEARCH OF STRATEGIES APPLIED TO SOLVE A PHYSIS PROBLEM BY PERSONS WITH DIFFERENT DEGREE OF EXPERIENCE AND DIFFERENT ATTITUDES TOWARDS PHYSICS EYE-TRACKING INVESTIGATION

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INTRODUCTION

Research into the interests of young people and the ways they make decisions when solving problems is one of the most important tasks of modern teaching. This is particularly important in those areas of human activity which are generally considered difficult. It applies, above all, to mathematics and natural sciences and especially to physics. Research conducted at the Faculty of Mathematics, Physics and Technical Science of the Pedagogical University of Krakow, as well as the studies conducted in other university centres, show that physics is considered to be the least interesting and the most unpopular school subject [Pęczkowski, 2009]. It is also known to be among the least interesting subjects in higher education. This remark also applies to young people in other countries [Sjeberg & Schreiner, 2007]. Interestingly, the dislike of physics is also indicated by students who claim to like mathematics, chemistry and other natural sciences. This aversion to physics seems to contradict the natural interest of young people in the surrounding world and their striving for knowledge and understanding of natural phenomena [Williams i in., 2003]. Indeed, children are known for their curiosity which, as they continue their school education, diminishes dramatically [Elbanowska-Ciemiuchowska, 2010]. The reason for this phenomenon is worth understanding and explanation. A large number of errors can be committed due to the lack of recognition of the interests of pupils and students, and ignorance of the causes of their difficulties, especially in the initial phase of education [Błasiak i in., 2012]. The aim of this study was to analyse the decision-making process in the subjects by observing the activity of their eyes when analysing the task.

We also studied the difference between eye activity while making effective and ineffective decisions [Madsen i in. 2012], and differences in the strategy of solving a problem by novices (including pupils and students) and experts (including PhD students and academics).

DESCRIPTION OF THE EDUCATIONAL EXPERIMENT

The tested group consisted of 103 persons, among whom there were (1) 9 PhD students of physics, 3 persons with a doctoral degree and one person with the degree of habilitated doctor of physics, the so-called experts (13 persons, 12.6%), (2) 55 computer science students, 7 students of mathematics, 2 students of physics and 2 students of biology, so-called students (66 people, 64.1%), and (3) students from the II class of one of Krakow's secondary schools (24 people, 23.3%). Among the experts, PhD students, and students were the staff and students of the Pedagogical University in Krakow, one of several higher education institutions in Krakow.

The experiment was conducted in the laboratory of neuro-didactics of the Pedagogical University in Krakow. The study used an SMI ultra-high speed 1250 H eye-tracker, whose camera recorded the movements of one of the eyeballs and conveyed information to a computer. The experiment consisted of three stages.

In the first phase of the experiment, we examined the declared level of interest in physics, the degree of intention of being a scientist and an opinion on the importance of physics to society [Błasiak i in., 2012].

Each of the subjects had to indicate on a scale of 0 to 10, how much they agree with the following statements:

1. I AM INTERESTED IN PHYSICS.
2. I WANT TO BECOME A SCIENTIST
3. I THINK THAT PHYSICS IS USEFUL TO SOCIETY.

The statements appeared on the screen and the subject's task was to answer by clicking on one of the squares numbered from 1 to 10.

In the second phase of the experiment, participants solved 10 physical problems at the level of difficulty of the curriculum in secondary school. These were questions where the participants had to choose one answer from among five options. The layout of the tasks included graphic elements and text. There were no time limits for making the decision. Eye movements, the duration of fixation and saccadic movements were recorded while solving the task. After the completion of each task, the subject was allowed a minute to listen to relaxing music.

In the third stage of the experiment, we once again returned to the three statements listed in the first stage, in order to study the activity of the eyes when answering.

In this article, we will describe and analyse the results related to solving the tasks testing the imagination of the respondents (the task with cubs). The results concerning the remaining tasks will be the subject of separate publications. First, we shall present the way the task was formulated and we will provide its correct answer, then we will describe the relationship between the answers given by the test subjects with the answers given for other tasks and with the three statements about the degree of interest in physics. Finally, we will concentrate on the activity of eyes while solving the problem, presented in the form of so-called heat maps.

TEST TASK

Figure 01 shows the screen which was presented when the subjects of this research were solving the task, whose content was "Two young lions run with the speed of the same, constant values along the shores of an island having the shape of a square with a side of length a. None of the cubs stop or turn around. Which of the following diagrams may show the length of segment d connecting the young lions, depending on time t." In the original experiment, the content of the task was in Polish.

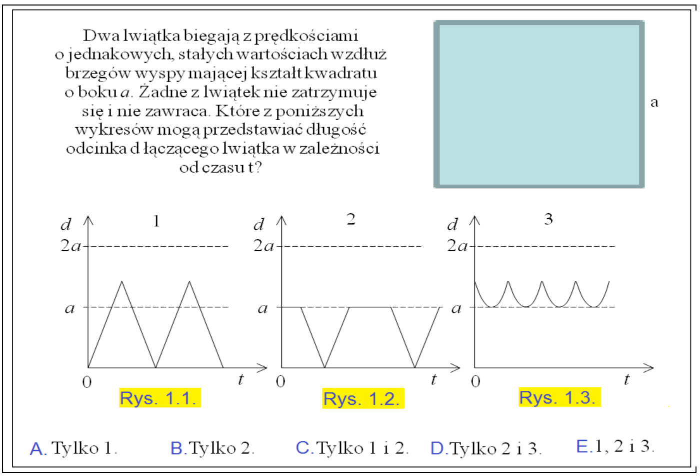

Fig. 01. A screenshot of the task in question.

It is obvious that the distance between the cubs can range from 0 (when the cubs are in the same location) to (When the cubs are in the opposite vertices of the square). In a particular case, the distance depends on the initial position of the cubs and the direction in which they move (same or contrary).

If the cubs are starting from different places and moving in the same direction with equal speed, they can never meet. If their initial distance is less than a (e.g., they are initially located on the same side), their distance will never exceed a. If the initial distance between them is greater than a (e.g., they start on the opposite sides), the distance between them is always greater than or equal to a. Figure 1.3 shows one such situation where the cubs are starting from two opposite corners of the square).

If the cubs run in opposite directions, they will always meet and the shape of the graph presenting the distance between them is dependent on their original orientation relative to each other and relative to the vertices. Figure 1.1 shows the situation where the cubs start from the same vertex and Fig 1.2, where they begin from opposite sides.

Table I shows the distribution of responses to the task with the cubs (in %) divided into three groups of study participants. (1) physics PhD students and experts, (2) students in mathematics and computer science (3) high school students. The only correct answer is the answer E.

Tab. 01. Distribution (in %) of responses in the task with the cubs.

	Group			Total
	Experts	Students	Pupils	
A. Only 1	23.1	33.3	33.3	32.0
B. Only 2	30.8	19.7	20.8	21.4
C. 1 and 2	23.1	30.3	29.2	29.1
D. 2 and 3		9.1	4.2	6.8
E. 1, 2, 3	23.0	7.6	12.5	10.7

It is clear that well over half of the people could see only options 1 or 2, while not being able to see option 3, in which the animals ran in the same direction. The difference between the groups is not large, but, significantly, more PhD students and experts provided the correct answer.

TEST TASKS AND OTHER QUESTIONS AND PROBLEMS

Those who correctly solved the task with the cubs, were also better at solving the other tasks. Table II shows the distribution in per cents. The relationship is statistically significant (p-value = 0.014).

Tab. 02. The dependence of response to the considered task of the number of correct answers in all tasks (score).

		Problem				
		A	B	C	D	E
Score	0	50.0%		42.9%	7.1%	
	1	40.0%	23.3%	26.7%	6.7%	3.3%
	2	23.8%	28.6%	38.1%	9.5%	
	3	27.8%	27.8%	27.8%		16.7%
	4	11.1%	33.3%	22.2%		33.3%
	5	33.3%	33.3%		33.3%	
	6	50.0%			25.0%	25.0%
	7					100.0%
	8			100.0%		
	9					100,0%
Total		32.0%	21.4%	29.1%	6.8%	10.7%

The average number of correctly solved tasks compared to each of the answers provided in the task with cubs is presented in Tab. 03. Among the correct answers in the task with the cubs (answer E), it amounts to 4.64 with a total average of correctly solved tasks equal to 2.25.

Tab. 03. The average number of correctly solved tasks for individual choices in the task with the cubs.

Problem	Score	Number of Persons
A	1.76	33
B	2.32	22
C	1.83	30
D	2.43	7
E	4.64	11
Total	2.25	103

In the following part of this work, we will consider the relationship between the answer provided in the task with the cubs and the answers to the questions about the degree of interest in physics. The participants of the experiment were shown the following three statements mentioned in paragraph 1 of this article.

Answers about the degree of identification with the above statements given before and after solving tasks were not identical, although the correlations were large (0.935 for statement 1, 0.959 for statement 2 and 0.936 for statement 3). On the other hand, the correlation between the various statements were smaller (0.774 and 0.807 for statements 1 and 2, 0.400, and 0.397 for statements 1 and 3, and 0.400 and 0.386 for statements 2 and 3). All correlations are significant at the level of 0.01, but one can see that the answers corresponding to statement 3 are more different from the responses concerning statements 1 and 2.

Mean values for the response on scale 0-10 reached respectively (standard deviation in brackets):
- At the beginning of the experiment (before solving the tasks): Question 1 5.17 (2.88), Question 2. 4.83 (3.20), Question 3. 7.78 (2.06).
- At the end of the experiment (after solving the tasks): Question 1a. 4.85 (2.92), Question 2a.

4.95 (3.17), Question 3a. 7.77 (2.05).

It is visible that the tested persons agree, in the highest degree, with the opinion that Physics is useful to society.

The test task was correctly solved by 11 people, and 88 people gave an incorrect answer.

Comparing this with the answers provided for statements 1, 2, 3 we have:
- For statement 1, the mean and standard deviation of 7.36 (1.86) for correct solutions to the task and 4.90 (2.88) for incorrect solutions to the task,
- For statement 2, the mean and standard deviation of 6.45 (3.14) for correct solutions to the task and 4.60 (3.14) for incorrect solutions to the task,
- For statement 3, the mean and standard deviation of 8.64 (2.16) for correct solutions to the task and 7.70 (2.02) for incorrect solutions to the task.

These differences are important for statement 1 at a level of 0.01, for statement 2 at a level of 0.05 and for statement 3 - they are negligible. The conclusion is that individuals characterized by a greater interest in physics and science were actually better with providing the solution to the tasks with the cubs. In contrast, the degree of appreciation of the importance of physics to society is of less importance for the correct solution of this task. One can be aware of the importance of the natural sciences to modern society, but at the same time, they may not be associating their future with physics and may not have the aptitude for solving mathematics and physics problems.

Figure 02 shows the distribution of responses for the task (correct, wrong) depending on the declared level of interest in physics.

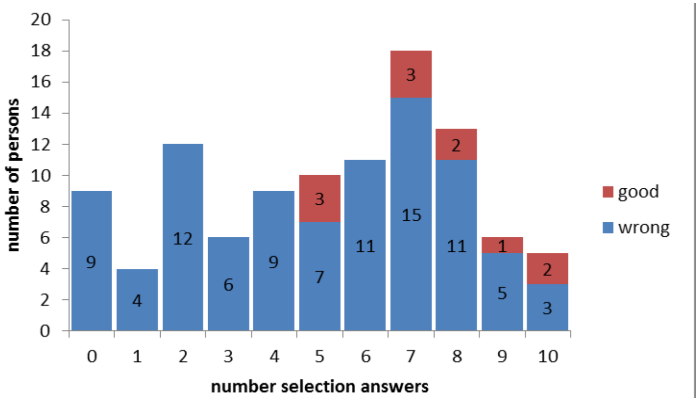

Fig. 02. Distribution of persons who solved the task with the cubs (correct, wrong) depending on the declared level of interest in physics.

Those more interested in physics achieve better results.

Figure 03. shows the distribution of responses for the task (correct, wrong) depending on the declared intent of becoming a scientist.

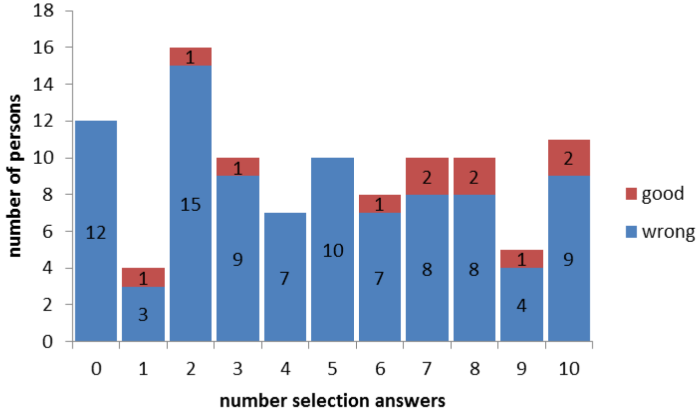

Fig. 03. Distribution of persons who solved the task with the cubs (correct, wrong) depending on the declared intent of becoming a scientist.

The relationship here is not large, it is not statistically significant at the level of 0.01

Figure 04 shows the distribution of responses for the task (correct, wrong) depending on the assessment of importance of physics for society.

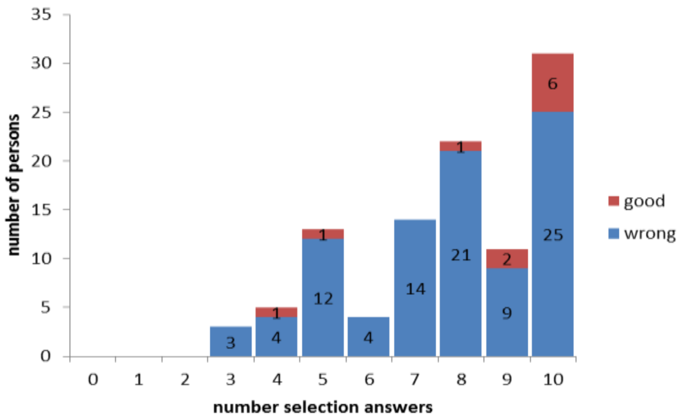

Fig. 04. Distribution of persons who solved the task with the cubs.

(correct, wrong) depending on the assessment of importance of physics for society.

This dependence (Fig. 04) is also not clear, it is not statistically significant.

HEAT MAPS

In the following part of this article we would like to present the main results obtained during the problem-solving task. We will present two heat maps showing how the tested group of people analysed the content of the task and chose the answer. The first map refers to the group of experts, and the second refers to the group of secondary-school students. The heat maps can be presented dynamically for each person, which will allow observing how the decision making process ran in time, but it is not possible to show this in a static article.

The heat maps allow one to present the intensity of the attention focused on the parts of the image data, which is measured by the number and time of fixation. This intensity is represented graphically by means of colours. The colour red indicates areas with the longest time of retaining the sight of the subject, and therefore with the greatest interest in the portion of the image, the next colours in order are: yellow, green, light blue and dark blue. Other areas (white) are places that did not raise interest in the tested person.

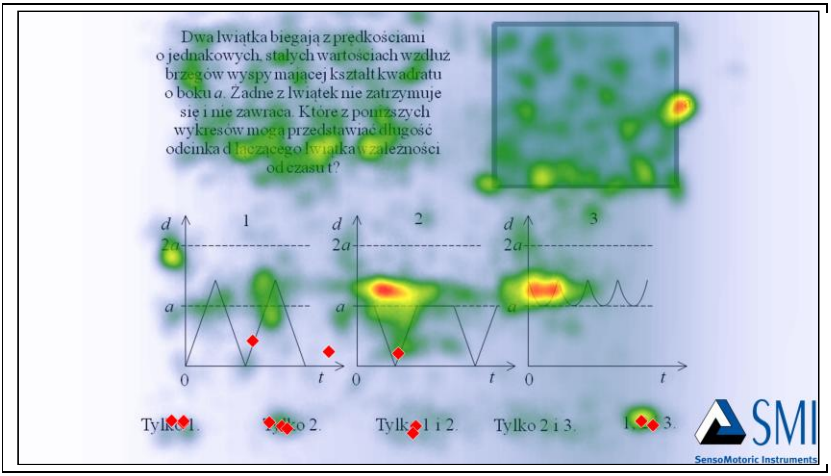

Fig. 05. Heat map - experts.

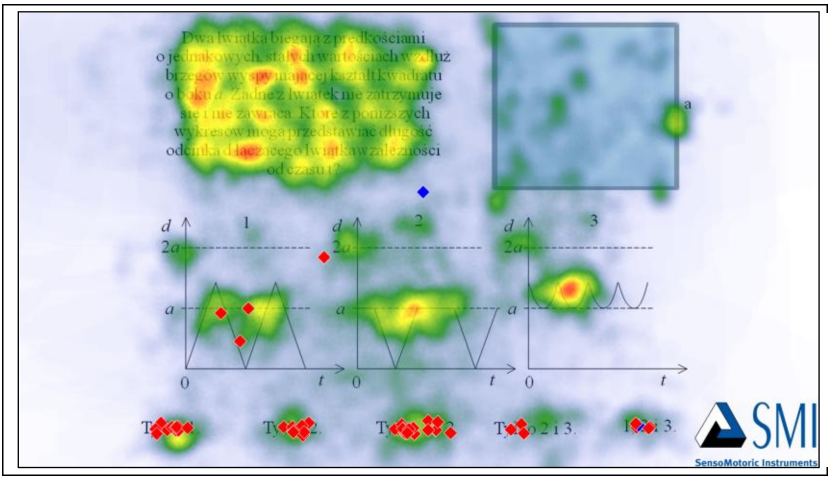

Fig. 06. Heat map - students.

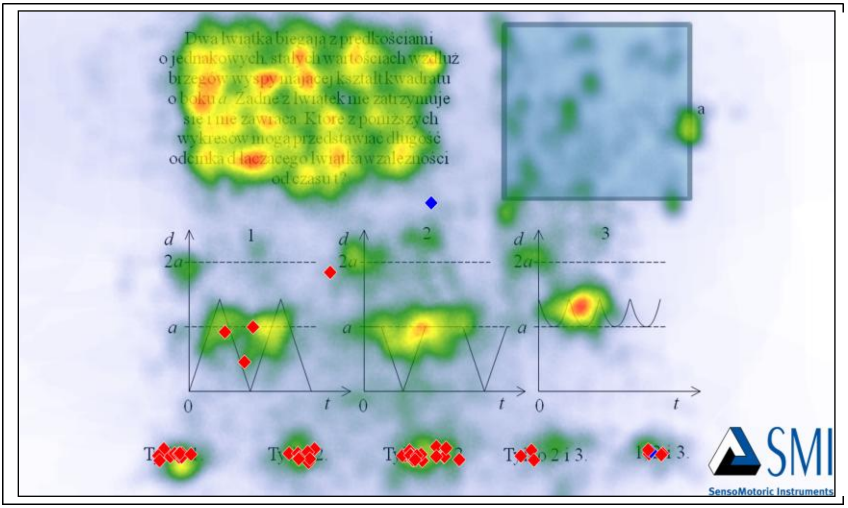

Fig. 07. Heat map – pupils.

The interpretation of heat maps is as follows. Experts devoted the most time to looking at the questions contained in the problem and to the right side of the square, and less time to looking at the formulation of the task (Kahneman, 2011). Of the three charts they devoted most attention to graphs 2 and 3. The students spend a great deal of time analysing the wording of the task and viewed all the charts to a similar extent. They devoted more time than the experts to reading the task, looked at the bottom side of the square and all the charts. All of them looked at the fragment of the square, where the length of the side is marked (point a). We can distinguish a few areas of greatest interest (area of interest - AOI), but not a single, coherent area.

INTERPRETATION OF THE RESULTS

When analysing the results of the experiment, it was observed that people who declared greater interest in physics, performed better in solving the main task as well as other activities occurring in the test [McGinnis & Bringing, 1992]. What is more, people with more experience, here called the experts, performed better than the students, treated here as novices. No such relationship was observed with respect to the assessment of the importance of physics to society. While solving the problem, there was no significant difference between the mean parameters describing the work of the eyes, i.e. duration and frequency of fixations and the speed of saccadic movements in the three distinguished groups of respondents (experts, students, pupils).

It is believed that the strategy used during problem solving is different for experts and novices. The longer average time of fixation on a specific fragment of the image indicates a greater cognitive effort associated with its interpretation. Long saccades, or eye shifts to distant parts of the image indicate a global search strategy. As noted by P. Francuz [Francuz, 2013], a global search strategy in the field of art (viewing paintings) is more characteristic for experts than novices (laymen). Our studies do not confirm this statement, if we apply them to the strategies of solving physics problems.

FINAL CONCLUSIONS

Our experiment provided information about the relationship with the declared level of interest in physics, the intention of being a scientist and an assessment of importance of physics to society and the effectiveness of solving a mathematics-physics problem by people with different levels of experience (academics, PhD students, students of physics and students of secondary schools). In explaining this relationship, we used the method of analysis of the eye movement of the participants while solving the problem and examined the interdependence of various parameters of eye movement (fixations and saccadic movements). We were unable to obtain satisfactory answers for many questions due to the fact that the differences between the tested groups turned out to be insignificant.

However, it seems worthwhile to subsequently research the differences in eye movement in various stages of viewing an image (e.g. at the beginning, when a participant examines the content of the problem, and at the end, when they make a decision).

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DIFFICULTIES IN LEARNING AND TEACHING QUANTUM PHYSICS

Paweł Pęczkowski, Władysław Błasiak, Roman Rosiek

Introduction

The subject matter of this article is to discuss the research on the difficulties in learning and teaching of quantum physics in high schools. They were supplemented with the studies carried out in secondary schools that may help to explain the causes of these difficulties. At Polish universities, the basics of quantum mechanics are taught mostly in the second or third year of studies as a single-semester or two-semester subject. The lectures are accompanied by practical classes or seminars devoted to problem solving. Prior to the start of classes on quantum mechanics, the students take part in a course on mathematical analysis with the probability calculus and linear algebra course.

Quantum mechanics is one of the most difficult subjects taught on physics faculty. Most students starting courses on quantum mechanics, in addition to the low level of mathematical preparation, also have many misconceptions acquired in secondary school during classes in the subject called “Physics and Astronomy”. The aim of the study was to identify these problems and make a diagnosis, which would allow overcoming these problems and would contribute to the development of such a course on “Quantum Mechanics”, which would be accessible and friendly for students.

Review of existing research in the world

In a review of previous research on the world, we presented the main conclusions from the research described in the literature:

Examination of the students’ knowledge of initial courses of physics - PER University of Maryland, USA [Hake, 1998].

Based on the research it was found that students have difficulties in conceptual understanding of quantum phenomena and using instructions, manuals and computer programs designed to help them understand the subject.

Research of students’ understanding of concepts related to potential well, wave function and probability, University of Maryland [Bao, Redish, 2002].

The research has shown that students tend to interpret a one-dimensional potential well as a two-dimensional gravity well. They also have difficulties in understanding the concept of negative total energy, use of statistical methods to describe a physical system and in a combination of energy with wave function.

Diagnosis of the state of knowledge of students starting to learn quantum mechanics, University of Sydney, Australia [Johnson et al., 1998].

The research studied students’ knowledge about the idea of quantization, light, model of the atom, photoelectric effect and photons, and found that the students memorize the facts that are of secondary importance for explaining quantum phenomena.

Study of difficulties in understanding the phenomenon of diffraction and interference, University of Washington [Ambrose et al., 1999].

The research studied the understanding of the phenomenon of single-slit diffraction and double-slit diffraction and interference. It was found that most students had trouble with explaining the phenomenon of diffraction and predicting the change in the diffraction pattern on the screen when the width of the slits is changed. Students were not able to interpret the diffraction and interference phenomena on the basis of wave models. For example, they treated the length of de Broglie wave as a fixed property of the particle, independent of momentum. The conclusion from the research was that students' errors are a consequence of interpreting quantum phenomena in classical way and mixing classical and quantum physics.

The study of teaching methods based on visual computer simulation of physical phenomena without referring to classical analogy, Kansas State University, USA and high school in Germany [Rebello, 1999].

As a conclusion of this study the authors proposed introduction of classical physics and quantum mechanics as two independent conceptual systems, resignation from Bohr's model and introduction of electron diffraction before photon diffraction.

Study of the relationship between students' achievements in mathematics and quantum physics, Ohio State University [Sadaghiani, 2005].

According to the author of the research, students do not understand the essence of the concept of probability and concepts related to probability, interpret the uncertainty principle as the inability to make precise measurements, equate probability with probability amplitude.

The conclusions of the study formulated an opinion that the partial knowledge of classical physics is not sufficient to deal with modern physics and new information can not simply be added to the already existing knowledge. It is believed that Newtonian physics, which is learned before quantum mechanics, can be an obstacle for students in understanding quantum concepts.

Research carried out

Until now, there has been no large-scale empirical research in the field of quantum physics teaching carried out in Poland. There was little study on this topic in other countries, and those that are described in the literature were carried out on small groups of students, often, from a single university. The basis for the conducted empirical studies were tests consisting of single- and multiple-choice closed tasks and open tasks consisting in performing calculations and interpretation of physical phenomena. According to the argument raised by the authors, the difficulties in understanding quantum physics come from poor (and in recent years in Poland even poorer) preparation of students completing upper secondary school in the knowledge of physics, mathematics and chemistry. Therefore, a large part of this article is devoted to recognizing the skills and the level of preparation in the field of quantum physics of students completing secondary schools. In secondary school, students are faced with a number of terms used both in classical physics and quantum physics, but quantum concepts are taught primarily in a descriptive way with putting stress to the interpretation of the phenomena. Preparation of secondary school graduates to study quantum mechanics has been tested by:

- analysing the results of selected matriculation tasks from "Physics and Astronomy" [2005 - 2008], on topics related to quantum physics and nuclear physics;
- analysing the results of a specially developed test carried out in 26 secondary schools in Poland.

In addition to testing the students filled out questionnaires concerning additional factors that could have an impact on the understanding of quantum phenomena such as:
- the number of hours of teaching Physics and Astronomy;
- the type and frequency of used textbooks;
- students' attitudes to the subject of Physics and Astronomy, and other subjects;
- participation in contests related to Physics and Astronomy.

The test for the students consisted of 30 multiple choice task concerning issues introductory to quantum physics and taught in secondary schools. The study was conducted on a sample consisting of 1153 high school students from various Polish regions, 886 of the students were in high school, and 267 in vocational schools. 909 secondary school students studied Physics and Astronomy at primary level and 244 at the advanced level [Pęczkowski, 2009].

Students learning of Physics and Astronomy at the advanced level have a greater number of hours devoted to this subject and learn from other textbooks. This level of teaching physics is chosen by students who wish to study science, technical or natural sciences. Those learning at the basic level solved the first 20 tasks including topics from basic level. Learners at the advanced level tasks solved all 30 test tasks and 10 additional computing tasks at home.

The study was conducted on a sample of 313 students of physics from 16 higher education institutions (14 universities, one academy and one technical college) in Poland. Students solved tests consisting of 30 tasks, prepared especially for the study. Apart from the analysis of test results, we carried out an analysis of the dependence of the results on the textbook used for the lecture, the number of hours of lectures and computational classes, the location of the lecture in the curriculum.

Study of the difficulties of high school students in understanding of quantum physics

Tasks for high school students were related to:
- classical properties of light;
- diffraction and interference of light;
- classical waves;
- photoelectric effect and photon energy;
- de Broglie waves;
- the uncertainty principle.

The analysis of the solutions of test tasks by the students will be presented on the example of two related tasks of checking the understanding of the corpuscular-wave duality.

A beam of light falls on the system of two slits. On the screen, we see fringes formed by light passing through the slit. After a significant weakening of the beam, we can register individual photons falling on the screen. In this case, a single photon:
- may hit any point of the screen, with the same probability,
- may only hit points where we previously observed interference maximums,
- may only hit points where previously were interference minimums,
- more often hits the points where previously were interference maximums and less frequently the points where the intensity of fringes was smaller than in maximums, and never hits the points where previously were minimums.

The same experiment as in the previous question can be carried out with electrons.

A beam of electrons falls on the system of two slits. On the screen, we see fringes formed by electrons passing through the slit. After a significant weakening of the beam, we can register individual electrons falling on the screen. In this case, a single electron:
- may hit any point of the screen, with the same probability,
- may only hit points where we previously observed interference maximums,
- may only hit points where previously were interference minimums,
- more often hits the points where previously were interference maximums and less frequently the points where the intensity of fringes was smaller than in maximums, and never hits the points where previously were minimums.

The first of these tasks checks whether students understand the essence of the phenomenon of single-photon interference and the formation of interference fringes. It diagnoses the problems of students in the field of relationships between physical phenomena. The latter task is similar to the first one, but it applies to electrons instead of light.

Both tasks have proven difficult. In the first task, the task ease factor was 47.9%, and for the basic and advanced levels - respectively 42.5% and 67.2%. The least frequently chosen answer was C (12.6%), which looks quite unnatural. Quite frequent and similar in terms of frequency, the choice of A and B answers shows that a large portion of students does not understand the essence of the phenomenon of interference of photons. Learners on advanced level obtained significantly better results than those learning at the basic level, but in both groups the wrong answers were chosen with similar frequencies, which may indicate guessing the answer by a large part of students.

Distribution of results of the task with electrons was similar to the task on the beam of light, but the correctness of answers was worse. Ease factor was 34.4%, and for the basic and advanced levels - respectively 29.7% and 52.0%. There was also a lot of nonresponse. This shows that students associate the phenomenon of interference with classical wave, such as electromagnetic wave and a wave on the water more often than with the wave behaviour of an object commonly known as a particle.

Of the 10 tasks designed exclusively for students studying at the advanced level, we will present a task designed to test understanding of the properties of quantum light proving the indeterminism of quantum phenomena.

The light beam emitted by the source falls on the beam splitter (*), behind which there are two detectors (see figure – Fig. 01). If a light source emits only one photon, it will be registered:

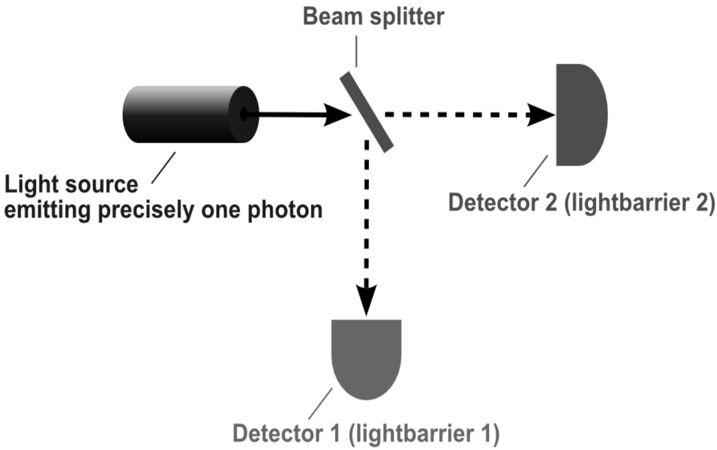

Fig. 01.

(*) Note: Beam splitter splits the beam into two beams with equal intensities and colour of the incident beam. This principle of "splitting" applies also for light with very low intensity.

only by the detector 1,

only by the detector 2,

by detector 1 and by detector 2 (both at the same time),

either by detector 1 or detector 2 (only one of them).

If we do not set the detectors in the right places, then we can not decide which way does the elementary particle go. The correct answer D indicates that a particle reaches one detector, but we can not guess which one. Due to the symmetry of the task, a thinking student should eliminate A and B and find the correct answer among the answers C and D. It turned out that both of these responses were selected with nearly the same frequency (respectively 35.7% and 41.8%), while answer B was chosen twice as often as the answer A.

The task diagnoses methodological difficulties of the students in application of research methods of quantum physics and understanding the phenomena of quantum indeterminism. The results indicate that the majority of students consciously rejected variants A and B, but guessed the answer from the possible C and D. Thus, the majority of students do not understand the essence of quantum determinism.

Study of the difficulties of higher-education students in understanding of quantum physics

The test for university students consisted of 30 tasks, some of which were multiple-choice tasks (they had a different number of response options), and some tasks were open, usually requiring calculations. The tasks were related to standard quantum mechanics course called “Quantum Mechanics I” or “Quantum Physics I”. The last two tasks went beyond the standard course. Lectures on various Polish universities differ in details, but the base is a common theme and includes:

- problems of classical physics, the historical examples of inadequacy of the classical theory and attempts to overcome them by the introduction of quantization and wave theory; presented here is an analysis of the diffraction-interference experiments for light and electrons (Young experiment, Davisson-Germer experiment),
- wave function and its probabilistic interpretation, together with a discussion of stationary and time-dependent Schrödinger equation,
- formalism of quantum mechanics, including Hilbert space as the space of wave functions, operators on the wave functions spaces, operators of physical quantities and how are they created, commutators, values and own functions, observables and their measurements,
- measurements of physical quantities and the formulation of the uncertainty principle with examples: momentum-position, time-energy,
- harmonic oscillator, potential well and barrier, the phenomenon of tunneling,
- hydrogen atom model in non-relativistic approximation,
- approximate methods for determining the function and own values, perturbation theory independent of time
- properties of particles with spin, Pauli matrices and spin operators,
- elements of the theory of groups, including the group of symmetries and conservation laws in quantum physics.

In some lectures, the lecturer introduces extensions of basic topics. They include, for example, Dirac notation, the orbital angular momentum in a positional representation, interaction of particles in a homogeneous magnetic field, interaction of atoms with electromagnetic wave, scattering theory, variational methods of Rayleigh-Ritz, quantum coherence, entanglement and teleportation.

As in the case of tasks for the high-school students, we will present examples of tasks for university students, and then we will discuss the findings of the test prepared for them. Tasks for students are grouped by subject:

- probability, wave function and its evolution in time,
- mathematical operators used in quantum mechanics,
- properties and measurement of spin,
- quantum measurement,
- symmetry,
- potential barrier,
- energy and degeneracy of quantum states,
- atom in magnetic field.

Understanding of the concept of the wave function

The first of the tasks presented in the article (task 2 in the test for university students) covers understanding of the concept of steady-state wave function. Similar task has been presented in (Sadaghiani, 2005).

Fig. 02 shows a graph of potential energy corresponding to the asymmetric infinite well. The well has a width of 2a, with the walls at the points x = ± a, where for and for .

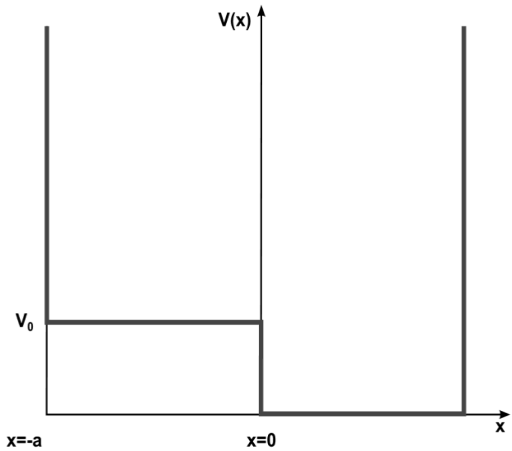

Fig. 02.

Two of the figures below (Fig. 03) do not show the steady-state wave function of a particle moving in this well. Identify these figures (Fig. 03) and justify your choice.

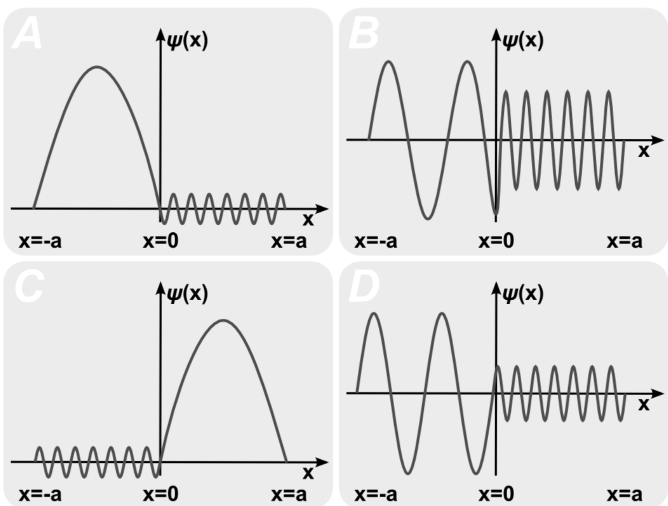

Fig. 03.

The students' task is to write which of the charts do not represent the wave function corresponding to the particle energy states. A student should justify their choice, allowing us to find out what their way of reasoning was and what are the difficulties in the case of incorrect answers.

The whole task was properly resolved by 7.7% of the students. Of the two correct answers (B and C):

answer B (chart rejection due to "terms of stitching" of the wave function) was chosen by 46.6% of students, and the answer was properly justified by 10.9% of them.

answer C (rejection of the chart because of the relationship of the kinetic energy of the particle with the length of de Broglie wave) was chosen by 41.9% of students, and properly justified by 8.6%.

Fig. 04 shows the distribution of two responses (from among A, B, C, D), and Fig. 05 shows the distribution of the reasons for selecting the correct answers B and C.

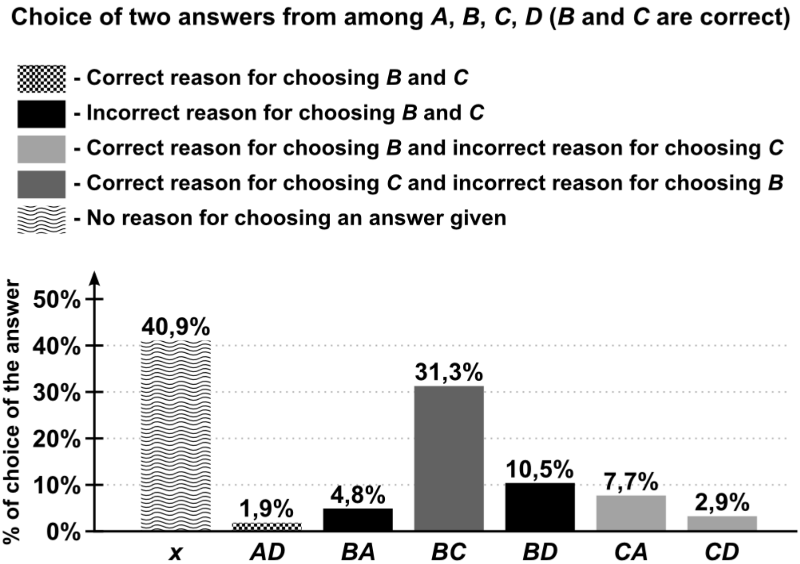

Fig. 04. Distribution of the two responses from among A, B, C, D

In Fig. 04 symbol "X" marks lack of response, so 40.9% of the students did not give any answer to this question.

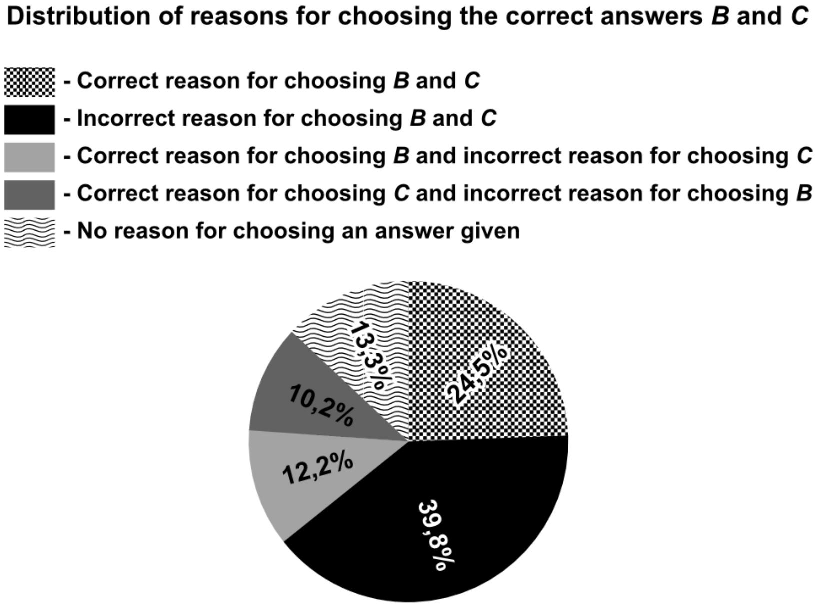

Fig. 05. Distribution of the reasons for selecting the correct answers B and C

Understanding of the essence of quantum measurements

The third task (task 20 in the test for university students), which we describe here, concerned understanding of the essence of quantum measurements.

The particle is in a quantum state described by the wave function, which, for takes the form:

$$\psi(x) = \frac{1}{\sqrt{2}}\psi_1(x) - \frac{1}{\sqrt{2}}\psi_2(x)$$

here $\psi_1(x)$ is the ground state of a Hamiltonian corresponding to energy E_1, and $\psi_2(x)$ is the ground state of a Hamiltonian corresponding to the energy E_2.

What are the allowed values of the particle energy in a single measurement?

What is the expected value of the energy of the particles?

What is the energy dispersion of the particles?

The task consists of three components, which check understanding of what is the measurement of the quantum state and the concepts of expected value and dispersion, which are associated with this measurement. Summary of results of how the students' solved this task is presented Fig. 06.

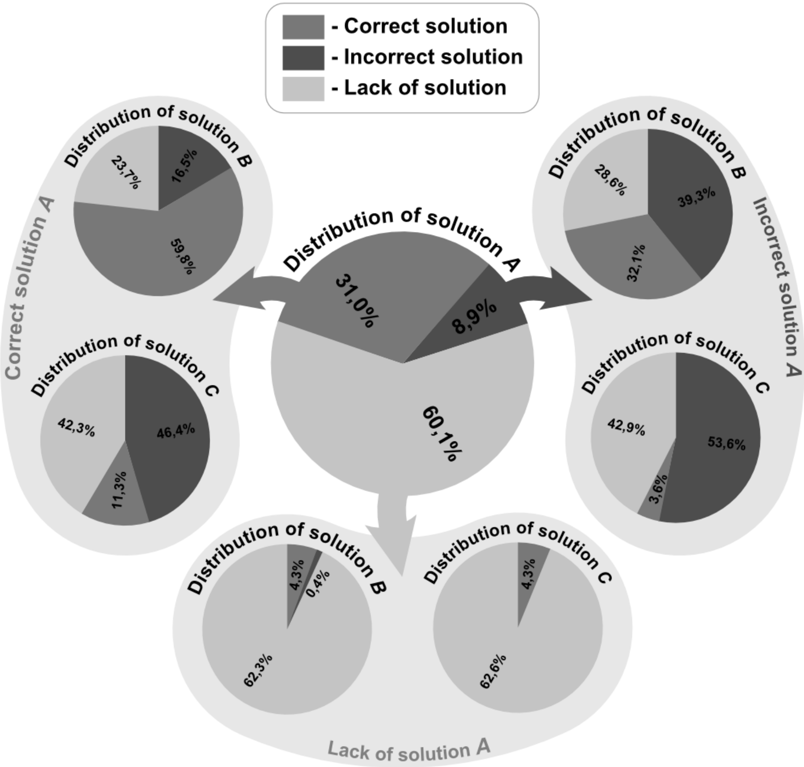

Fig. 06. Summary of the results of solutions of the task (task 20 in the test for university students) provided by students.

The ease factor of the first part of the task was 31.0%, and thus was quite low. This testifies to the fact that a large proportion of students does not understand the essence of the particle energy quantization described by the wave function. The ease factor of the second part of the task was 21.7%. This part of the task was correctly solved by 68 people (21.7%), and 206 people (65.8%) did not give any answer. Few students gave the correct answer to the third part of the job. The ease factor was 3.8%, and nearly 75% of students solving this task did not give any answer. Sometimes, instead of dispersion students provided standard deviation, which indicates that many students also confuse these two concepts.

Understanding of the difference between classical theory and quantum theory in explaining physical phenomena

We added two tasks to the test for university students that involved topics not covered in the standard course of quantum mechanics. This means that the subject matter of these tasks is not realised in a typical courses of quantum physics, and perhaps some of the tested students, in the opinion of some of the teachers, did not learn about it in class. It can be expected that the ease factors of these tasks are, due to that, quite low.

On the basis of the classical theory molar heat of molecular hydrogen (H_2) is $C_V = \frac{5}{2}R$ and does not depend on the temperature T. Fig. 07 shows the dependence of the molar heat of C_V on the temperature T H_2. How can we explain the observed dependence $C_V(T)$ by means of quantum theory is shown in Fig. 07.

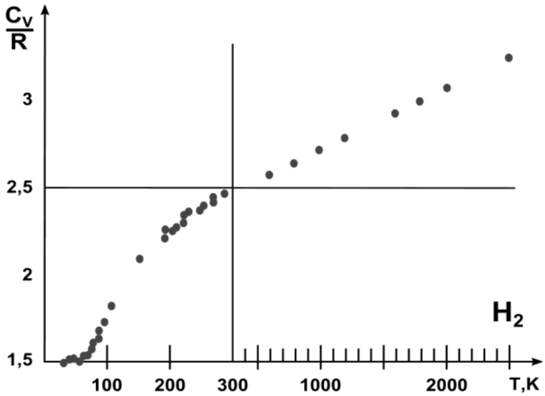

Fig. 07.

This task tests the student's ability to explain the difference in the course of the physical phenomena described by means of classical theory and quantum theory. The correct answer was provided by 34 people (10.9%), thus, the ease factor of the task was 10.9%. The task proved to be very difficult. The course of the phenomenon considered in the task is utterly beyond comprehension in classical theory, and can be properly explained only in the context of quantum theory. The answers given by most of the students indicate that they do not understand the idea of quantum theory in explaining physical phenomena.

Hydrogen (H) and chlorine (Cl) atoms in a HCl molecule are, on average, distant from each other by $1{,}27 \bullet 10^{-10}$ (Frequency of oscillation is $\upsilon_{osc} = 0{,}37$ ev/h, where h is Planck constant). Calculate the difference in energy between the ground state of the molecule and its vibrational-rotational levels with one rotational excitation and one oscillation excitation.

Useful constants:

atomic weight of hydrogen $M_H \approx 1{,}0$ u,

atomic weight of chlorine $M_{Cl} \approx 35{,}5$ u,

atomic mass unit $1\text{u} = 1{,}66 \bullet 10^{-27}$ kg,

$\hbar c = 2 \bullet 10^{-13}$ MeV • m

The task checks the knowledge of the dependences connected to energy difference between rotating and oscillating states of molecules and understanding of the energy quantization of the rotational oscillation spectra of diatomic molecules. The task also checks skills such as: carrying out calculations with physical formulas transformation, conversion of physical units including the use of the information provided in the task. The diagram of rotational oscillation levels of the HCl molecule with permitted transitions which facilitates solving the task and the emission spectrum corresponding to allowed transitions and the oscillating-rotating absorption spectrum for HCl in the gaseous state are given in [Eisberg, Resnick, 1983].

The correct answer was provided by 9 students (2.9), so the task is very difficult. The result of solving this task also suggests that the majority of students does not understand the basic ideas and the aim of introduction of quantum theory. They can not cope with non-standard tasks that have not been discussed and explained in lectures and classes.

Summary of the results of the test for university students

Summarizing the results of the test for university students, it can be concluded that the easiest tasks included the evolution of the wave function, the tasks connected with spin and energy particles passing through the potential barrier. The most difficult proved to be the tasks concerning the Stern-Gerlach phenomenon and associated with the calculation of the expected value of mixed states with the use of density operator, the tasks related to electron interference pattern and the tasks concerning the energy scale of rotational and vibrational levels of an HCl molecule and the heat values at low temperatures.

From the analysis of the results of the tasks for students, we can conclude that in a quantum physics course at university level, the shortcoming in mathematical preparation present themselves more clearly than among high school students. This applies, above all, to the concepts of probability, whose lack of understanding makes it difficult to interpret the wave function, quantum measurement and interpretation of the Stern-Gerlach experiment. Students have trouble with determining the probability density, which consists on normalizing the function and calculating integrals. Shortcomings in skills of infinitesimal calculus and the calculus of matrix make themselves apparent. The second group of problems are the difficulties in interpretation.

In solutions of the tasks, we noted many errors caused by:
- misunderstanding of time evolution of the ground state of Hamilton
- inability to write the wave function in terms of function’s ground energy,
- lack of ability to interpret the behaviour of an elementary particle after passing through the potential barrier,
- lack of knowledge of interpretation of the solutions of Schrödinger equation,
- lack of knowledge of position-momentum representation,
- inability to calculate the expected values of ground states with the use of the operator’s density,
- confusing magnetic orbital and magnetic spin quantum number,
- failure to understand the consequences of symmetric and antisymmetric functions’ properties.

The difficulties students have include also the lack of ability to accurately read the content of the tasks and a number of accounting errors.

As in many previous studies carried out in the world, it was found that understanding the basic ideas of quantum mechanics and contrasting them from the ideas of classical physics pose a great difficulty for many students. Superstitions and false beliefs about the physical world acquired in the early stages of learning physics are difficult to eradicate and correct when teaching university students in the traditional way.

The introduction of quantum mechanics required a different approach to the world from the researchers, and hence familiarizing themselves with quantum mechanics, requires a new approach to the world and development of a new way of thinking also from the students. Developing new ways of thinking, combined with qualitative recognition of quantum mechanics should reduce or eliminate the confusion in understanding quantum concepts. Research shows that it is possible to explain basic quantum concepts to students who meet with quantum mechanics for the first time, without the need for advanced mathematical apparatus [Farrell, 1993 and Roussel, 2000]. Visualization, together with simulations illustrating the course of quantum phenomena with the use of computer graphics programs, facilitates the development of scientific knowledge and understanding of quantum phenomena under consideration.

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PUPILS' REPRESENTATIONS ABOUT THE TRANSFORMATIONS OF ENERGY: THE CASE OF SIMPLE ELECTRICAL CIRCUIT

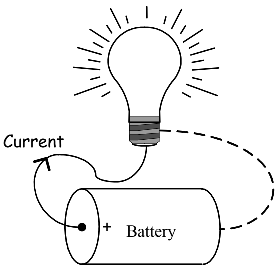
Abdeljalil Métioui, Louis Trudel

The context and purpose of the framework

Numerous research demonstrate that in order to explain the working of a circuit composed of a battery, a bulb and two electric wires, the majority of the pupils refers to one of the three following models:

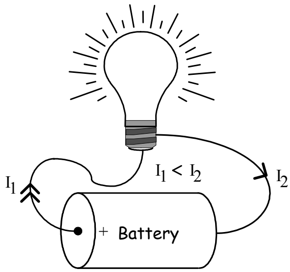
THE UNIPOLAR MODEL

The electric current leaves from the battery and arrive to the bulb (the wire back toward the battery is considered useless and passive).



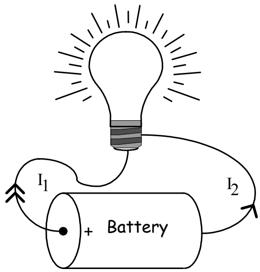
THE CURRENT CONSUMED MODEL

Part of the current is consumed by the bulb.



THE CLASHING CURRENTS MODEL

The currents leaving from the boundary-marks (+) and (-) of the battery meet in the bulb.



These models are erroneous compared to the scientific model. In this model the intensity of the electric current is the same in all point of the circuit in accordance with the principle of the conservation of the charge. The present research appears in this perspective and has for objective to identify the conceptions of forty-six (46) Quebec (Canada) pupils aged from 10 to 12 years about the energy transformations in a simple electric circuit? Let's note that our review of the literature didn't reveal research related to this topic.

Methods

The data collection came from a "paper-pencil" questionnaire made up of six questions: (1) let's consider a circuit constituted of a battery, a bulb and wires to make an electrical connection. If one leaves the bulb lit during a few minutes it becomes hot; according to you why does it become hot? (2) According to you, from where comes the light in the bulb? (3) According to you, is there a difference between electricity and light? (4) According to you, is there a difference between electricity and heat? (5) According to you, what is inside a battery? 6) What is electricity for you? The answers of the pupils were grouped one question at a time. For each question, a classification of the answers was made in different categories, their number differing from one question to another, according to the given answers. Then, an interpretation was made of the answers identified in each of the categories in order to specify the most widely spread explanations.

Results

Analyses - Question 1: This question served to know how the pupils explain the warning up of a bulb in an electric circuit. The data collected revealed 5 categories of answers:

Category 1: Warming up of the filament in the bulb. “In the bulb there is a metal part as in a frying pan and well when it is lit, it becomes red and it is that that makes the heat.” (e10)	11%
Category 2: Releasing of the heat by the light. “The light heats up the lamp and it (the heat) remains blocked to it (the bulb), becomes hot and when we shut it off, the bulb becomes cold.” (e4)	17%
Category 3: Releasing the heat by the hot electricity. "Because electricity is hot. Electricity passes through the filament too long, the heat accumulates and, through the bulb, the heat comes out of the bulb and warms up." (e12)	12%
Category 4: Accumulation or the passing through, either of electricity, either of a hot energy, either of the heat in the bulb. "If it remains a long time, the current that remains trapped in the bulb cannot get out anymore, so what remains with the energy makes the heat." (e34)	20%
Category 5: Fuzzy, incomplete or indecipherable answer. "It is because of the heat that the bulb gives off. When it remains lit too long, this is what happens. " (e32)	44%

Analyses - Question 2: This question served to know how the pupils explain the source of light. The data collected revealed 4 categories of answers:

Category 1: Light comes from electricity stored in the battery. "From the battery that gives electricity right up to the bulb." (e42)	5%
Category 2: Light comes either from the energy, either from electricity, either from the liquid (hot) that is in the battery. "From the energy of the battery." (32)	28%
Category 3: Light comes from the filament of the bulb because of the electricity of the battery. "This light comes of the electricity of the wires in the bulb." (e6)	37%
Category 4: Fuzzy, incomplete or indecipherable answer. "The bulb has two small metal wires that have a V shape and there is a loop in between the V, when they are joined by a wire, the energy that is in the battery is going to pass through the two wires and they are going to light up." (e4)	30%

Analyses - Question 3: This question served to know how the pupils to specify the difference between electricity and light. The data collected revealed 3 categories of answers:

Category 1: Electricity produces light - electricity is a sort of light and light (except the Sun) is a sort of electricity. "No because light is made with electricity." (e25)	42%
Category 2: Electricity and light don't have the same uses - light cannot produce electricity and without electricity, there is no light. "Electricity it current that passes through a wire and light is something that is hot, mixed with electricity it makes light." (e39)	12%
Category 3: Fuzzy, incomplete or indecipherable answer. "No, because light goes quickly and electricity also." (e28)	46%

Analyses - Question 4: This question relates to a possible difference between electricity and heat. The data collected revealed 3 categories of answers:

Category 1: The heat is hot, electricity also - electricity contains the heat. "No because heat is part of electricity." (e25)	20%
Category 2: Electricity and the heat don't have the same properties: danger, light, warming up, etc.). "Electricity is the current that passes through a wire and heat is something that is hot like a bulb." (e39)	30%
Category 3: Fuzzy, incomplete or indecipherable answer. "Heat is hot, electricity is not hot but it becomes hot as soon as it touches a conductor." (e44)	50%

Analyses - Question 5: This question is on the composition of the battery. The data collected revealed 5 categories of answers:

Category 1: There is electricity and wires in a battery. "Inside a battery there is electricity, it is the reason for making light nevertheless strong." (e26)	17%
Category 2: There is either liquid acid, either mercury, either oil, either a gas, either a chemical that releases or retains electricity in a battery. "Gas to create light." (e21)	35%
Category 3: There is either energy, either a force, either volts in a battery. "In the battery, there is the current, energy, coal and oil." (e39)	13%
Category 4: There are only wires in a battery. "Wires that operate the battery and that could operate electric things." (e2)	7%
Category 5: Fuzzy, incomplete or indecipherable answer. "Electric wires, iron, plates." (e10)	28%

Analyses - Question 6: This question is on what is electricity. The data collected revealed 5 categories of answers:

Category 1: Associates electricity to light. "Electricity is light and heat from a stove." (e16)	17%
Category 2: Evokes the utilitarian aspect of electricity. "It is something very important. Examples, the telephone, the television, the hot water, light, the radio. " (e21)	24%
Category 3: Evokes the dangerous aspect of electricity. "A current that makes light move and it is something dangerous." (e9)	11%
Category 4: Evokes the notion either of energy, either of electrical current, either of force, either of power. "It is energy that passes through a wire or a bulb." (e39)	13%
Category 5: Fuzzy, incomplete or indecipherable answer. "For me, electricity is life." (e30)	35%

From the analysis of the answers it is possible to infer the following representations: (1) light is as hot as the Sun, therefore it warms up the lamp; (2) electricity coming from the battery heats up the filament in the bulb and releases heat that remains in the glass bulb; (3) the electricity that passes through the filament warms it up because electricity is hot; (4) electricity produces heat that remains in the bulb and it sticks on the glass that warms up; (5) the electricity of the battery, while going through the filament, releases heat that warms up the bulb.

Conclusions and implications

The results demonstrate that there is only a minority of pupils who has some representations in continuity with the scientific concepts related to the transformations of energy within a simple electric circuit. Therefore, there are some advantages to begin the instruction with identifying the previous representations of the pupils, mobilizing them, and offering learning situations that encourages them to put their representations to the test in scientific activities.

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PRIMARY STUDENT TEACHERS' MISCONCONCEPTIONS ABOUT ELECTROSTATIC

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The context and purpose of the framework

There are several researches about the conceptions of preservice and inservice teachers at the primary school with respect to the basic notions in physical, chemical and biological sciences [Métioui & Baulu Mac Willie, 2013; Métioui & Trudel, 2010; Pina, Messer & St-John, 2001; Valinides, 2000]. The present communication appears in this perspective and wants to put in evidence the conceptions of 94 teachers. Thus, to identify their misconceptions, we distibuted them a paper-pencil questionnaire of a sixty minutes. The questions were associated to events with which they are daily in interaction and whose assimilation requires the understanding of the phenomenon of production of the charges and their displacement, as well as of the law s between opposite charges.

Questionnaire

To this end, we formulated four questions: (1) how do you explain that while brushing your hair, it sticks to your comb if it is dry? (2) While rubbing a ball (of feast) in our hair, one can make it hold at the wall. How do you explain this phenomenon? Why does it ends up falling after some time? (3) How do you explain that while rubbing our feet on a carpet by a dry day, can one catch an electric shock while touching a metallic door hand? (4) How do you explain the formation of a lightning during a storm? Let's note that in the curriculum of the primary schools of Quebec (Canada), one finds notions associated with this field. Also, the majority of the participating teachers had followed, at the time of their secondary studies, some electrostatics notions in attending an introductory physics course.

Methods

The data analysis took place in two stages. Firstly, we compiled the answers, one question at a time, each taken separately. For each of them, we proceeded to the classification in distinct categories, the number of which being variable from one question to the other, according to the different gotten answers. This categorization started by making the distinction between the good and the wrong answers and the incomplete or indecipherable answers. To qualify the answers as advanced of correct or wrong, we compared them to those commonly accepted by scientists. Secondly, we interpreted the answers classified in categories in order to identify the most widespread explanations.

Results

Analysis of the first question

The first question is about the phenomenon of electric attraction between charged objects. Rubbing the comb on the hair causing a transfer of electrons, the comb will end up with a deficit of electrons and will become therefore positively charged. Hair being charged negatively, therefore there is an excess of electrons and, according to the law of the charges, they will attract each other. Of course, if the hair is wet, the water will prevent the transfer of the electrons because of the polarity of the water molecules, whereas while charging the hair by rubbing it by dry time, they will stand upright, in accordance with the law of repulsion between charges of same signs. The answers given by students permitted us to note the absence of correct explanations. We identified raised five categories of answers as presented below; each of these categories is illustrated with an example of answer. In order to personalize information while preserving anonymity, the students were identified by the symbol ei (ième student).

Category 1 (27%) - Hair “glues” to the comb because of the rubbing between the two: “Rubbing creates static electricity. It is this electricity that passes from one hair to the other when it knocks to the comb. ” (e13)

Category 2 (27%) - Hair “glues” to the comb because it is about static electricity: “Because of the static electricity, but I am incapable to describe the phenomenon.” (e42)

Category 3 (7%) - Hair contains statics: “It is because there is statics in hair.” (e19

Category 4 (13%) - Hair “glues” to the comb because opposite charges attract: “Because there is a rubbing between the comb and hair and this causes the negative and positive charges that attract.” (e30)

Category 5 (26%): Use of the scientific terms in a way that is confused, incomplete or indecipherable, or no answer: This produces an electrical reaction that will make your hair rise.” (E81)

Analysis of the second question

The justifications advanced by the students about the second question on the rubbed ball that one can make holding to the wall permitted us to identified three categories of answers:

Category 1 (7%) - The ball stores a charge opposed to the one of the wall : “While rubbing a ball on our head, we charge it of energy, for example positive and it holds to the wall because it is negative. After a few second, it ends up falling because the ball unloads the charge and becomes negative again.” (e20)

Category 2 (44%) - The static electricity that one puts to the ball by rubbing it: a) will make it hold to the wall; b) will make it glue to the wall. The ball will fall when this electricity will dissipated or decreased: “The static electricity produced by rubbing will make the ball holding to the wall according to the static electricity that passes through. However, this one only lasts a moment and it is for it that the ball falls thereafter.” (e8)

Category 3 (49%) - Use the scientific terms in a way that is confused, incomplete or indecipherable, or no answers: “The statics in our hairs made so that the ball can hold on the wall. The ball ends up falling because of the gravitation that attracts all objects toward its center.” (e19)

Analysis of the third question

The explanations advanced by the students about the question 3 on the shock that one can receive while touching a metallic handful or as touching another person after having rubbed our feet on a carpet by dry time allowed us to identify four categories of answers:

Category 1 (33%) - The charges produced by rubbing pass (or are transferred) from our body to the metallic handful (the electrons transfer themselves as shock): “By rubbing, one can produce the statics. Then, when one touches something that conducts electricity (metal or no one), the static electricity travels to the object and one catches a shock. ” (e8)

Category 2 (9%) - The human body is conductor of electricity: “Our body is a conductor. Electricity manufactured by rubbing springs of our body by our fingers.” (e52)

Category 3 (12%) - Affirm implicitly or explicitly that the shock results from the attraction between two opposite objects (the hand and the handful): “The static electricity contained in the carpet passes to our foot and all our body and while touching metal or another person, one takes a shock because they also have some.” (e82)

Category 4 (47%) - Use of the scientific terms in a way that is confused, incomplete or indecipherable, or no answer: “This phenomenon is provoked again by static electricity. There are some electrons in the carpet.”(e10)

Analysis of the fourth question

The explanations about the question 4 on the reason of the lightning during an electric storm allowed us to identify five categories of answers presented below.

Category 1 (16%) - The meeting of a cold forehead and a hot forehead. Meeting between the particles of hot air and cold air. The rubbing of two drafts (hot and cold): "I believe that it is an electric discharge provoked by the meeting of a cold forehead and a hot forehead." (e11)

Category 2 (14%) - The lightning results from the collision or rubbing between two clouds, or between air and the clouds, or between the atmosphere and the drops of water: "I believe that it is because of the rubbing of the cloud with air." (e1)

Category 3 (14%) - The lightning results from a meeting (or of a collision) between two opposite charges. The lightning results from the action of the positive and negative charges in the clouds or two different surroundings in the atmosphere: "The clouds are charged positively or negatively and when they knock themselves, they produce electricity (a lightning)." (e19)

Category 4 (5%) - The lightning results from a transfer of charges between the clouds or the sky (charged) and soil: "It is an electric discharge. The clouds are charged of positive electricity and the Earth of negative electricity and at the time of a storm, these two poles want to join themselves." (e45)

Category 5 (51%) - Use of the scientific terms in a way that is confused, incomplete or indecipherable, or no answer: "The heavy and humid time stores droplets of rain. This humidity enters in conflict with the big heat that is there." (e52)

In spite of the formulation that varies according to the presented situation, it seems that the students interpret the various electrostatic phenomena mainly while referring to three explanations. The first puts into play opposite charges whose interaction seems to justify the observed phenomenon. The second interpretation of the phenomena observed refers to a mechanism of equilibrium that redistributes the charges between the objects. The third interpretation leans on an accumulation of charges and its possible out-flow when some conditions are fulfilled.

Conclusions and implications

The results of this exploratory study demonstrate that it would be necessary to work more on the explanations given by the students with respect to electrostatic phenomenon while questioning them on several related situations. Their setting in shape would permit to identifiy the erroneous conceptions and to clarify their nature.

Then, one could create educational situations in order to overcome or avoid them. Otherwise, in a teaching context, one must concentrate on the atomic structure of matter so that the students can understand the nature of the electric charge, what doesn't seem to be clear considering their answers.

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Teaching and Learning Biology at all Levels of Education

MBL Activities Using IBSE: Learning Biology in Context

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Introduction

Project COMBLAB

The contribution presents a methodology of creation and implementation of six biology activities based on inquiry education approach and using probeware in laboratory, microcomputer-based laboratory, MBL. Activities were created within a European Comenius multilateral project COMBLAB (*competency microcomputer-based laboratory*) named *The acquisition of science competencies using ICT real time experiments*, that is now in its final third year of existence. One of the project objectives is to create synergies among six partners interested in probeware and MBL: (1) Universitat Autònoma de Barcelona (Spain), (2) Charles University in Prague (Czech Republic), (3) University for Teacher Education Lower Austria, Vienna (Austria), (4) Universitat de Barcelona (Spain), (5) University of Helsinky (Finland) and (6) Matej Bel University in Banská Bystrica (Slovakia). Partners have been working on developing and testing new designed chemistry, physics and biology activities for MBL. Other important COMBLAB output is to disseminate activities among school teachers and to create network of teachers using MBL in their teaching practice. 1.2 IBSE approach in microcomputer-based laboratory

COMBLAB partners agree with previous researches made on MBL efficacy in science education (e. g. Redish et al. 1997). Gathered data from sensor projected on screen allow real time visualization of monitored variables. These immediately obtained data in graph skip a need of plotting the data manually. Therefore students have more time for interpretation and analysis that happens often simultaneously with gathering data itself. MBL also enables performing experiments that present variables difficult to observe in traditional arrangement. Generally accepted advantage is a possibility to perform experiments with special time requirements (e. g. long-termed observations in biology or short-termed experiments in physics).

The team of COMBLAB researchers agreed on designing activities involving students in learning process that would make sense and reveal the application of formerly remembered knowledge. At first, the predict-observe-explain (POE) concept was accepted by the team. To emphasize the aspect of students' own impact on designing the experiment in given context, the inquiry based science education (IBSE) approach was implemented as well. IBSE approach is recognized for its efficacy at primary and secondary level when increasing students' interests in learning process and teachers' motivation at the same time and positive impact on students' IT skills and cooperation and communication competencies by working in groups (Barnea et al 2010, Hofstein et al 2005). This approach can also help to build mental models of chemical phenomena by developing higher-order thinking skills (Aksela 2005).

Methods

Refining didactic sequence

To fulfil the requirement of an inquiry-based biology activity the traditional cook-book instructions were abandoned and the didactic sequence was refined (Šmejkal et al 2013). The newly developed activities are designed in scheme that can be divided into several parts:

(1) Engagement: at the beginning students are introduced in a situation or relevant context that aims to arouse interest and curiosity (story, problem to solve). From the introduction the initial question arises. First tasks (2 - Warming up) usually relate to students' previous knowledge (counting, variables) and to learn how to use the MBL equipment (purpose of using a particular sensor). After getting know to sensors, students model the real situation, design an experiment according to their suggestions and perform it in a laboratory (3 - Experiment designing and

conducting). (4) Drawing final conclusions: when students measure the data they interpret the obtained data or can change the experiment set up if they are not satisfied with the results and make final conclusions that correspond with the data. In the end they (5) communicate the results not just in conclusion, but they have to apply their new knowledge to communicate the conclusions e.g. in email to their friend or in a letter to the magazine that received reader's question.

Implementing, testing, revising

The main authors of six biology activities created according to refined didactic sequence are researchers from Department of teaching and didactics of chemistry (Charles University in Prague). Preliminary versions of activities were prepared and sent for feed-back to partner from Matej Bel University (Slovakia) and to a colleague at the department of biology education, Charles University in Prague. New revised students' worksheets with implemented suggestions were prepared in Czech language, then translated to English and to local languages (Catalan, German, Finnish, Slovak). Prepared biology activities were implemented and tested during autumn 2013 at the department of chemistry of Matej Bel University (Slovakia) with secondary school students from four grammar schools. Implementing and testing in the Czech Republic was carried out in spring 2014 at three Czech grammar schools and with a group of students at the laboratory of department of biology education. The testing brought useful experience that led to creating the re-revised versions of the activities.

Results

Biology activities – students worksheets and teachers guides

Currently, the final versions of six biology activities in Czech and English are available: the activities involve the issue of influencing life conditions - fermentation (Life of yeast), plant topics photosynthesis (Is it safe to sleep in bedroom full of plants?) and germination (Wake up, seed, wake up, it's time to get up!), human issues electrocardiogram (What makes your heart flatter?) and blood pressure (Doctor's assistant), and ecologic issue eutrophication (Plant predators). Parallel to students' worksheets the teachers' versions were prepared: at first, the hints for teachers were coloured in students' versions, finally the teachers' guides consist of part with students version on the left and the commentary part for teachers on the right. Teachers can find there the results of warming up tasks, expected answers, tips for arranging the experiment, tricky parts of the experiment, often mistakes made by students, expected results and specific questions that can be given to students in the end of laboratory lesson to find out whether students understood the activity and the obtained results.

Implementing and testing in the Czech Republic

Two schools from Prague were involved in testing the activities and one secondary grammar school from Moravian town Třinec; in total 5 teachers implemented the biology activities in their laboratory lessons. For evaluation of prepared activities, three evaluating tools were administered to students: before performing the activity students were given a pre-test for motivational orientations and after the activity the post-test for motivational orientations; these tests were adopted from Pintrich at al. (1991) and McAuley at al. (1989). The third research tool – a COMBLAB questionnaire, was also distributed after performing the activity. It is related to activity itself and brings important feedback on how students perceive each activity, what do they like and dislike the most and other aspects. Detailed information about the concept and evaluating method of used questionnaires can be found in the article of Marek Skoršepa (Matej Bel University) concerning the results from Slovak Republic.

The first author of presented contribution was one of the teachers implementing the activities with first grade students (age 15-16) at Masarykova secondary school of chemistry. Therefore, we want to present some results coming from observation during eight laboratory courses and emerged from discussions with colleague also implementing the activities in four laboratory courses with first grade students.

Regarding students, they got used to work with probeware easily, as they are used to work with notebooks, tablets or smartphones. However, the teacher's help with the software was still needed at the beginning. For about half of the students the concept of the activity was problematic. Despite, it is guided inquiry, the instructions were too vague for somebody and some students did not know how to design the experiment without the teacher's help in a way that would bring reasonable results. Another problem was drawing conclusions: students were rarely able to formulate the conclusions on a paper from comparing the graphs, although when asked by teacher they understood the meaning of the graphs. And when they had to communicate the results, some of them perceive it as useless that could be seen in the level of finally-written letter/e-mail. The context of the activity was well accepted, but rather by younger students than by older ones (comparing with the preliminary teachers' notes from Třinec testing and from last year testing at Masarykova school). Older students seem to prefer shorter introduction because they want to focus on experimenting – this observation needs more research. The design of worksheets was acceptable for students, although it was unusual at the first laboratory. They were able to answer the prediction parts, especially graphs, but mostly with poor verbal description. Their description of the procedure was usually very weak, as it was not reproducible. As sometimes the rewritten results/graphs were not schematic, they were inapplicable for further analysis.

Microcomputer-based laboratory places demands also on teachers. They have to master complex competences: not just soft skills, such as IBSE, facilitating students, managing work without direct instructions, being ready to improvise a lot, but also hard skills such as using the probeware, which means sensors and cooperating software. Furthermore, the teachers have to be ready to solve unexpected technical problems (sensor does not want to connect automatically, the software crashes, etc.). These problems represent an element of uncertainty for teacher that can discourage him/her from MBL usage. On the other hand, it is satisfactory when a teacher sees how students can work independently on precise instructions, how they plan their own work, design the experiment in various ways and develop different competencies than in instructional laboratories. Inquiry approach in MBL also brings opportunity for weaker students, who can for example handle the computer or they surprisingly come with elegant solution of given problem. In all cases, a teacher has to be instantly ready for help and new student's ideas, which is a perfect way for him/her to stay open-minded to scientific thinking.

Conclusion

Six biology activities using IBSE in MBL have been prepared within the project COMBLAB. Despite the subject biology, the issues are exploitable also in other science subjects (or in physical education) that can be supported by the fact that testing of these activities were done by chemistry teachers in lessons of chemistry laboratory with no students objections. At the beginning of implementing inquiry based MBL, there is the obstacle of time: students have to be used to inquiry from previous experiences and they should be able to handle the probeware and software. Solution to this is performing short demonstrational MBL experiments by teacher in the science subjects, when the graph is projected on screen – students get passively familiar with the software interface. More difficult is an acceptance of MBL by the teachers: the initial output takes a lot of teacher's time and energy and the effectivity is not seen at the beginning. Moreover, some technical problems and results that sometimes differ from expected ones bring the element of uncertainty to teaching process that meets teacher's resistance. According to our experience, these factors mostly cause the teachers rejection of using MBL in science. Authors see MBL as an important connection between school and real laboratory work. Therefore, one of the solutions can be preparing teachers for using MBL during their study in pre-service teaching. Another important aspect of using MBL is the context of experiment, as in real laboratory the instrumental devices are used to solve given problem. If the context of experiment will also make sense to students, their learning becomes meaningful.

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Teaching and Learning Chemistry at all Levels of Education

CHEMISTRY TEACHERS' OPINIONS OF CHEMISTRY EDUCATION

Martin Rusek, Iva Metelková

Introduction

Teachers' awareness of their students' attitudes towards a subject is an integral part of their teacher competences. It plays a vital role during didactical transformation of subject matter [Knecht, 2007]. Without proper didactical transformation the educational process is just about transferring information with the risk that students will receive nothing but empty words and symbols – such education has just a negligible effect.

It's the attitudes which determines students' motivation, their future study or work field and, last but not least, their attitude towards everything chemistry related in their future adult life. Students' attitudes are one of the most important educational outcomes in this respect [Rusek, 2013].

Nevertheless, researches conducted in the field of attitudes towards science usually aim only at students. This paper is focused on partial results of a research conducted on secondary schools chemistry teachers. The aim was to find out how much teacher's opinions on student's attitudes differ from the real state. This knowledge belongs among very important teacher competences as students' attitudes influence education to a great extent and didactical transformation of subject matter must be built also on this knowledge [Knecht, 2007]. Comparing teachers' opinions of their students' attitudes reflect the above mentioned teacher's competence.

The research described in this paper follows a research conducted on secondary school students by Rusek [2013]. For the research, the following secondary school students division was used: grammar schools, vocational schools with scientific/chemical direction and vocational schools with non-scientific/chemical direction [Rusek, Havlová, & Pumpr, 2010].

Methods

Research question and hypothesis

The research was driven by this research question: *How much do secondary school students' attitudes towards chemistry and secondary chemistry teachers' opinions of Chemistry Education vary? Students' attitudes towards chemistry* are their feelings, imaginings and values related to particular field (school subject), which is an object of science, school science, the effect of science on society or scientists themselves [Osborne, Simon, & Collins, 2003] expressed in a student questionnaire. *The Chemistry teachers' opinions* are represented by a set of teachers responses to a battery of questions used in students' attitudes questionnaires. Based on this question it is possible to formulate the following hypothesis:

H1: There is no difference between students' attitudes towards Chemistry and teacher's opinions on chemistry education.

It is necessary to distinguish between general education (grammar schools – Gymnázia) and vocational education (vocational and apprentice schools). After the school reform on the secondary level in the Czech Republic, Chemistry has been added into educational programmes of fields where it has not been before [Rusek & Pumpr, 2009].

In case the hypothesis is confirmed, the teachers understand their students, are aware of their attitudes therefore are able to transform the subject matter to a form fit for their students. However, the bigger the difference between students' and teachers' answers is, the less are the teachers able to adapt chemistry education to their students. This relation is vital also for the comparison between the group of grammar school students (and teachers) and vocational school students (and teachers) as it is important to treat a marginal subject (Chemistry at vocational schools) differently [Rusek, 2013].

Questionnaire creation

The research followed one conducted on secondary school students [Rusek, 2013] where a questionnaire assembled from attitude measuring questionnaires used by Prokop et al. [2007], Veselský & Hrubišková [2009] and Salta & Tzougraki [2004]. The questionnaire consisted of three parts: general attitudes, didactical means used in education and attitudes towards particular topics of chemistry education. For the purpose of this teacher oriented research, the same questionnaire was used, only the statements in the questionnaire were in conversed formulation. Compared to the questionnaires used for the research on students, the first part of the teachers' questionnaire contained also two extra questions enlisted in the first half of the questionnaire. Teachers responded on a four point Likert scale. The questions were following:

To what extent do you agree with these statements about chemistry education? (Strongly agree, agree, disagree, strongly disagree):

1a My students like Chemistry better than other school subjects.

1b Conducting demonstration experiments in Chemistry is boring for my students

1c As soon as they finish this school, their Chemistry knowledge will be good for nothing.

1d Chemistry is for students one of the easiest school subjects.

1e They can explain some phenomena around themselves based on what they learn in Chemistry.

Special questions for teachers only

There is a sense in teaching Chemistry on every type of secondary schools.

The classical system of Chemistry Education: general chemistry – inorganic chemistry – organic chemistry – biochemistry is optimal.

How often has this situation occurred in your Chemistry lessons? (Very often, often, hardly ever, never):

2a The lessons were boring.

2b I enjoyed teaching Chemistry.

2c The subject matter I taught was related to a real life.

2d The subject matter I taught was related to other school subject.

2e I found my students dull.

Questionnaire administration

First year secondary school students' attitudes towards science were examined in September and October 2012 with the use of the questionnaire [see Rusek, 2013]. Teachers' opinions were for the purposes of this research collected in October and November 2013.

The questionnaires were in both cases sent via emails and by post to schools collected schools. All the students attended secondary schools in Central-Bohemian Region with the exception of randomly selected vocational, science oriented schools from Moravian-Silesian Region and South-Moravian Region. The first group of addressed teachers were the teachers teaching at schools in Central-Bohemian Region which took part in the students' attitudes research. Therefore there is a potency of comparing the students' data to their teacher's opinions. In order to ensure a sufficient sample group, teachers from the South-Bohemian Region and Moravian-Silesian Region were addressed. Further information on the respondents is enlisted in the tab. 01.

Tab. 01. Responednt information Students and Teachers.

Students									
grammar school		lyceum		voc. Sci		voc. SLE		voc. CA	
G	B	G	B	G	B	G	B	G	B
75	42	46	31	26	38	129	68	92	49
64%	36%	60%	40%	41%	59%	65%	35%	65%	35%
117		77		64		197		141	
Σ 596									

Teachers			
voc.		G	
76		42	
63%		37%	
F	M	F	M
68	8	36	6
Σ = 118			

Legend: G – girls, B – boys, voc. sch. Sci – science oriented vocational schools, voc. sch. SLE – vocational school with school-leaving exam, voc. sch. CA – vocational school with the certificate of apprenticeship

The results were typed into MS Office Excel where they were analysed. For more advanced operations IBM SPSS Statistics 21 software was used.

Results

In order to compare the teachers' opinions, it's necessary to introduce the students' attitudes first. The results are listed in Tab. 02.

Tab. 02 Table of aritmetical means expressing particular answers.

Category	**Min**	**Max**	**Nr. of questions**	**Mean**						
				G	Lyc	Voc. Sci	Voc. SLE	Voc. CA	T G	T Voc.
Interest	0,5	3,5	2	1,80	1,83	1,95	1,79	1,76	2,05	2,08
Usefulness	0,5	3,5	4	2,23	2,14	2,06	2,10	1,99	2,62	2,62
Difficulty	0,5	3,5	2	1,48	1,60	1,61	1,64	1,65	1,91	1,90
Teacher	0	3	1	2,24	2,23	2,23	2,19	2,19	2,26	2,17
Experiments	1	4	1	3,45	3,33	1,66	1,81	1,90	3,18	3,33

Legend: G – grammar schools, Lyc – lyceum, voc. Sci – science oriented vocational schools, voc. SLE – vocational school with school-leaving exam, voc. CA – vocational school with the certificate of apprenticeship

The line between positive and negative results is in 2 for the first three categories, in 1.5 for teachers and on 2.5 for experiment. Even though the arithmetic mean gives us just orientation information, it is possible to observe some values. For closer information about statistically significant differences (confidence level 95 %), the data were analysed using ANOVA model. Particular significantly different values were further tested with the use of LSD test. These methods enable testing answers for every single question, therefore

As the differences among the student groups were described by Rusek [2013] attention will be paid only to the differences among teachers' and students' responses. For better transparency, average means and statistically significantly different values are presented in tab. 03. The values are calculated between grammar school teachers and grammar school students and vocational school teachers vs. vocational school students.

Answers to all the questions are introduced further in the text. They are worded in the way they were in the teacher's questionnaire. For 1a *My students like Chemistry better than other* *school subjects* the vocational school students with the exception of the Voc. Sci group answered more negatively than their teachers thought. The slightly negative responses may, however, be caused by the formulation of the question. Vocational students (with the exception of lyceum students) are generally not expected to like school subjects.

For 1b *Conducting demonstration experiments in Chemistry is boring for my students* all the groups differed with the exception of lyceum students. Whereas vocational school students with the exception of the lyceum students consider experiments less interesting than their teachers, grammar school students enjoy experiments more than their teachers think. For the question 1c *As soon as they finish this school, their Chemistry knowledge will be good for nothing* all the groups showed significant difference. Both vocational school and grammar school teachers seem not to be able to transfer their conviction about importance of chemistry knowledge in real life.

Tab. 03. Average means and P-values among.

		Questions									
		1a	1b	1c	1d	1e	2a	2b	2c	2d	2e
Mean	Voc T	2,28	3,33	3,19	1,85	3,10	1,89	2,17	2,17	2,00	1,96
	lyc	2,03	3,33	2,22	1,91	3,09	1,64	2,23	1,73	1,51	1,29
	sci	2,42	1,66	1,92	2,23	2,95	1,48	2,23	1,86	1,49	0,98
	SLE	1,92	1,81	2,47	1,93	2,69	1,66	2,19	1,74	1,50	1,36
	CA	1,96	1,90	2,40	1,81	2,44	1,57	2,19	1,68	1,46	1,50
P-value	lyc	0,260		0,000					0,000	0,000	0,000
	sci		0,000	0,000	0,001		0,007		0,016	0,000	0,000
	SLE	0,000	0,000	0,000		0,003	0,052		0,000	0,000	0,000
	CA	0,002	0,000	0,000		0,000	0,012		0,000	0,000	0,040
Mean	G T	2,21	3,18	3,13	1,89	3,09	1,89	2,26	2,20	2,07	1,94
	G S	2,06	3,45	2,21	1,82	2,90	1,54	2,24	1,98	1,83	1,14
P-value			0,016	0,000			0,025			0,051	0,000

In reference to the type of schools in the Sci group the answers for 1d *Chemistry is for students one of the easiest school subjects* will not be commented as they are expected.

In vocational school teachers' answers to 1e *They can explain some phenomena around themselves based on what they learn in Chemistry*, it is possible to see teachers' tendency to answer what they think is right and not according to the reality.

Interestingly, the results for 2a T*he lessons were boring* express both group of teachers consider their lessons slightly boring for the students. However the students agree the Chemistry lessons are boring. This finding seems to collide with answers to 2b *I enjoyed teaching Chemistry* the students as well as the teachers rather *agree* their teacher (they) enjoyed teaching chemistry.

The above mentioned boredom may stem in the didactical transformation of the Chemistry subject matter with respect to real life. Among the vocational school respondents to 2c *The subject matter I taught was related to a real life* and between both groups for 2d *The subject matter I taught was related to other school subject* the results differ significantly. It seems teachers fail to demonstrate interdisciplinary relations in the way sizeable for students. They agree that the subject matter was related both to real life as well as to other school subjects, nevertheless their students express either neutral or slightly negative opinions.

In the last question of this part of the questionnaire 2e *I found my students dull* teachers probably wanted to be politically correct and answered rather positively when they did not agree with this statement. However their students especially those at voc. Sci and grammar school felt a lot different (lowest score *I felt dull – agree*).

Conclusion and discussion

The insufficient time in proportion to the amount of the chemistry subject matter together with substantiated presumption the goal of education is more often to go through the subject matter rather than to teach it causes that students in the fields where chemistry is a marginal subject are not provided enough evidence about its use in everyday life.

Especially at grammar school it signifies experiments are very well received and might help rising students' attitudes towards chemistry. Another positive finding is teachers enjoyed teaching but lessons were boring (from their and also students' point of view). This indicates a promise that teachers want to teach, only do not know how to make their lessons interesting for students. This might help increase students' attitudes [cp. Salta & Tzougraki, 2004].

The results of the presented research are in accordance with previously conducted researches [see Prokop, Tuncer, & Chudá, 2007; Veselský & Hrubišková, 2009]. The comparison with teachers' opinions, though, brings new insight on factors influencing students' attitudes. Further steps in this fields will be directed on the Chemistry education content as differences in students' and teachers' opinions on particular topics play vital role in educational process.

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ATTITUDES AND ACHIEVEMENTS OF HIGH-SCHOOL STUDENTS IN CHEMISTRY

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Introduction

Influence of students' attitudes on learning various school subjects and learning in general is not new in scientific researches. When considering students' interest for learning chemistry, research showed that their attitudes affect significantly, while the education level of parents is not considered to be a factor that influences, nor the gender of students. The attitudes and beliefs of students towards chemistry are influenced by the media and the dominant beliefs within the culture. Students achievements are very important in many aspects: they are used by teachers when choosing appropriate methods and concepts they need to teach; they show students what do they know in certain part of a subject and direct them towards their future professional orientation; they show parents what kind of knowledge, skills and values their children are learning in school.

The impact of attitudes on learning chemistry

Clark and Macquarrie [2002)] showed that populations of many European countries have negative opinion regarding chemical industry, and a consequence can be negative attitude of young people towards chemistry as a science they encounter with during their education. Studies on students' attitudes and achievements in chemistry, and professional teaching practice itself show significance of a positive attitude towards chemistry on achievements. Bušac [2003] found that students, whose parents have positive attitude towards certain school subject, also have positive attitudes towards it, and higher marks. Tocci and Engelhard [1997] with better achievements in chemistry also have more positive perception of chemistry; they consider it as an important and useful subject. Most Greek secondary school students have neutral attitude toward chemistry as a school subject, but their attitude towards chemistry as a future professional orientation in mostly negative [Salta, 2004]. Kan and Akbas [2006] showed that there is no significant difference in attitudes towards chemistry among genders, and a positive correlation between attitudes and achievements in chemistry at secondary school level.

Students' achievements in chemistry

Students' achievements clearly show what kind of competencies – expected knowledge, skills and attitudes do students have in certain period of their education. They do not explain detailed themes that students should have learned (Curriculum), and they are not instructions for teachers regarding their teaching. Achievements are directed to students and their activities. Some standards for secondary school students that achievements point at are: understanding of significance of chemistry, knowing fundamental chemical concepts and terminology and their application [Trivić & Jankov, 2007]. The teachers' role is particulary emphasized because he/she needs to teach in a way that is acceptable for every student.

Methodology

The aim of this study was to determine the attitudes of students towards chemistry, to evaluate their achievements and to determine if there is correlation between them. In this study participated 100 first-grade students from one high school (gymnasium) in school year 2011/2012. Participants were surveyed by 5-point Likert-scale based questionnaire 1 (Q1, 10 items). Based on these results students' attitudes towards chemistry were estimated and students were divided into three groups (students with positive attitude, students with neutral attitude and students with negative attitude). Then the information was gathered from school archive about the students' achievements in chemistry at the end of the first semester of the first grade. After one month, and after the incorporating demonstration experiments into teaching process, students were tested by knowledge test (KT, 17 items including multiple choice and open ended questions, and one stoichiometric task, max. 20 points) and surveyed by 5-point Likert-scale based questionnaire 2 (Q2, 10 items). Based on these results, the re-categorization of students according to their attitudes toward chemistry was made, and students' achievements on KT and data from school archive were compared.

Results

This study gave us interesting and valuable data on high school students' attitudes towards chemistry, and their achievements that we could compare them with.

Attitude towards chemistry can be analyzed from three aspects: attitude towards chemistry education, towards chemistry as a school subject and towards chemistry teacher (Table 01):

Tab. 01. High school students' attitudes towards aspects of chemistry

Attitude towards:	Students (%)					
	Questionnaire Q1			Questionnaire Q2		
	Positive	Neutral	Negative	Positive	Neutral	Negative
Chemistry education	67,0	23,0	10,0	70,0	23,0	7,0
Chemistry as a school subject	67,0	20,0	13,0	67,0	26,0	7,0
Chemistry teacher	73,0	23,0	4,0	73,0	20,0	7,0
Mean ($\bar{x}$)	69,0	22,0	9,0	70,0	23,0	7,0

While we expected a negative attitude towards chemistry from these students, based on our earlier experience, however, the results showed that majority of students have a positive attitude (hypothesis tested with chi-square test; $\chi 2$ (Q1) = 2,45; $\chi 2$(Q2) = 3,95).

On Figure 01 we can see the slight increase in number of students with overall positive attitude towards chemistry education and neutral attitude towards chemistry teacher and chemistry as a school subject.

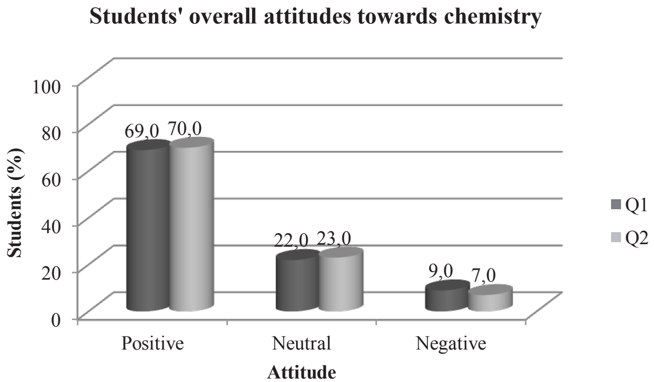

Fig. 01. Students' overall attitudes towards chemistry

There is a high correlation between the number of students with a positive attitude before and after teaching with demonstration experiments (ɼ = 0,86). There is slight increase in the number of participants with positive attitude towards chemistry, and science subjects in general.

Research results also showed that the achievements of participants are in correlation with their attitudes towards chemistry.

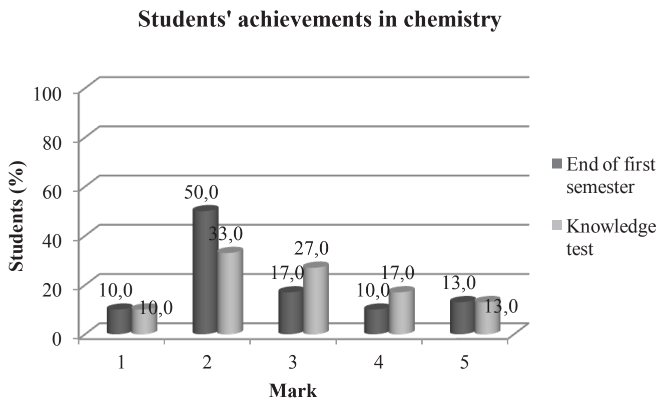

Fig. 02. Students' achievements in chemistry.

It is also determined that there is high correlation (ɼ =0,83) in students' achievements in chemistry at the end of the first semester and at the knowledge test in chemistry. There is no significant difference between students' achievements at the end of first semester and on test of knowledge, which is confirmed by statistical parameters (Table 02).

Tab. 02. Statistical parameters of students' achievements.

Statistical parameter	End of first semester	Test of knowledge
Mean	2,66	2,90
Mode	2	2
Median	2	2
Standard deviation	1,195	1,193
t-test	0,114	
Pearsons' test of correlation	0,8305	

Conclusion and implications

Formation of students' attitudes towards chemistry is a long process affected by a number of factors. Educational outcomes (students achievements) are also formed during continuous work of students and their teachers. Great responsibility is on the teacher, but she/he is not the only one that attitude towards chemistry and students achievements depend on. Creative teachers who teach chemistry with enthusiasm, who want and know how to enable students to acquire new knowledge, will succeed in making their students interested in the content they teach. In order to do so, teachers need to be educated continuously through seminars, workshops, and to use active teaching methods and resources.

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Teaching and Learning Medicine at all Levels of Education

CAN HOME COUNTRY OF STUDENTS STUDYING MEDICINE IN ENGLISH INFLUENCE THEIR SUCCESS IN BIOPHYSICS?

Zuzana Balázsiová, Eva Kráľová

The context and purpose of framework

The aim of study was to determine the impact of the student´s home country (school system, content and scope of study in high school, forms and methods of study ...), on the results of biophysics study provided in the first year of medical studies. This article presents an analysis of test results English speaking students from biophysics.

Methods

The research sample included 192 students, who have studied in English. The number of students from each country is presented in table 1. One student come from Belgium, Brazil, Iceland, Italy, Norway and France.

There were used the same teaching methods for teaching process. The original repetition didactic test was written by students after five practical trainings from (bio)physics. The test contained five open-ended questions, whose solution required the completion of exercise from practical training. Three of them were focused on medical biophysics (liquids, optics, electrical properties of biological tissue, physical units and radioactivity) and two were focused on statistical evaluation of measurement results (average, median, mode, absolute and relative errors and characteristics of variability). Students get 1 point for each correct answer. We calculated average and standard error. Results of students from different home country we compared by single-factor analysis of dispersion ANOVA. Result was statistically significant if $p \leq 0.05$.

Tab. 01. Number of students (n) from each country.

Country	Germany	Greece	Spain	Slovakia	Poland	Japan	Iran	USA	Austria	Cyprus
n	53	68	25	13	6	3	5	3	5	7

Results

(Bio)physical part of test

We found, that differences among results of English speaking students from different home countries are not statistical significant ($p>0.1$) (Tab. 02). We found statistically significant differences only in physical units knowledge – their using and conversion ($p=0{,}033$). Slovak and Polish students were the most successful. Everybody got 1.00 points in average. In other hand Italy, Cypriot and Belgium students got only (0.25 ± 0.09) points in average.

Tab. 02. Statistical probability (p) of difference level of (bio)physical knowledge of English speaking students.

Focus question	p
Global result of (bio)physical part	0,54
Microclimatic factors	0,94
Optics	0,3
Electrical properties of biological tissue	0,69
Radioactivity	0,42
Mechanics of liquids	0,7
Physical units (using, conversion)	0,033*

The most successful results we identified in radioactivity knowledge. Majority of students reached maximal success except students from Germany, Greek and Spain. Other difficult topic was optics. There weren´t any correct answers of students from Cyprus and Iran. Electrical properties of biological tissue were problem for Austria students. Every student got only (0.22±0.20) points in average. The best result was (0.47±0.08) points in average for students from Spain, France, Cyprus, Norway and Iceland. Measurement of microclimatic factor was difficult topic, too. There were the best result (0.53±0.24) points in average for Austria students. The worst result was (0.3±0.18) points in average for Slovak students.

Statistical part of test

Table 03 shows differences in successful of English speaking students for statistical tasks in dependence on their home country. Differences among topics about average, median, mode were not statistically significant.

Tab. 03. Statistical probability (p) of different levels of statistics knowledge for English-speaking students. (* statistical significant differences).

Focus question	p
Global result of statistics part	0,0073*
Average, median, mode	0,73
Error of measurement	0,019*
Variability characteristics	0,05*

The most successful were answers about error of measurement. Slovak and Polish students got maximal - 1 point in average. Less successful were answers of students, which home country is not in Europe (Iran, Japan, Brazil and U.S.A.) They got only (0.25±0.13) points in average.

The best answered on question about characteristics of variability students from Austria. Every student got (0.83±0.13) points in average. Students from Italy, France, Iceland, Belgium and Norway made the most mistakes. They got only (0.17±0.14) points in average.

In generally Austria students achieve the best result of statistical part of test ((0.72±0.11) point per student in average). The lowest average score have reached students from Belgium, Iceland, Italy, Norway and France. It was (0.23±0.12) points.

Conclusion and implications

Evaluation of test showed that study results from (bio)physics are independent of English speaking students home country, but results of statistical part of test depend on students home country extremely significantly. There are statistically significant differences in conversion of physical units at (bio)physical part of test. Statistics have been taught at a lecture and one practical exercise, only.

The assumption, that English speaking students at the beginning of study abroad are able to easily acquire knowledge and skills in the parts of (bio)physics, which they studied in high school, was confirmed. Students differently understand and manage differently those parts of the educational content, which are completely new to them, or they met it in different contexts, in different method of teaching or in other subjects. Success of learning these topics probably depends on basics knowledge acquired in their home country (assuming the students in this country have completed secondary education). Students do entrance examinations (only from biology and chemistry) at our faculty in English.

In addition to basic knowledge for students is important level knowledge of English. Kibler [2014] notes that foreign students traditionally score lower than their English-fluent colleagues on standardized tests because they are being assessed in a language in which they are not yet skilled.

Students in most cases use English, which they have learned at school - it is not their mother language. The academic English is one of the lots of elements, which are needed for successful manage of subject matter by ELL students. [Kibler, 2014] They acquire it during educational process. Fenner and Kuhlman [2012] wrote the basic rules for teaching foreign students whose native language is not English. We consider that academic English is other of the more reasons of larger differences among students. We expect that the completion of the course in biophysics in English reduce differences, which were identified in biophysical part of test.

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THE ROLE OF CONTEXTUAL LEARNING FOR THE FORMATION OF COMPETENCES FOR MEDICAL STUDENTS THROUGH PRACTICAL TRAINING IN CHEMISTRY

Vasil Hadzhiiliev, Zhaneta Stojkova, Veselin Ivanov

Introduction

One of the approaches discussed in university didactics is the contextual approach through which teaching in higher education is oriented toward the students' acquisition of direct professional experience. One way to achieve this is by placing and awarding credits for carrying out practical work in a specific professional environment. The relationship between academic knowledge and the professional skills of the students is particularly relevant in light of the Bologna Process and the EU growth strategy Europe 2020.

The notions of context and contextual approach in didactics point to the recognition of the role of the environment and the specific conditions under which the particular professional work takes place. These notions helped shift the centre of the educational programs from formal academic requirements to actual practical implementation [Petrova & Stoykova, 2011,p. 79].

Discovering the meaning on the part of the learner is one of the main characteristics of contextual learning. The meaning of what is being taught is related to the particular experience of the learner. It is individual and is constructed by each student, not by the teacher and his or her intentions, i.e. individual meaning arises from the interaction between the theoretical knowledge and the environment in which a pattern is revealed, and this leads to contextual learning (Jonson, 2001 p 4).

According to Borko and Putman [Borko &Putnam, 1998 p. 38, 41], contextual learning includes the following required components:

Situational learning. The theories about situational learning focus on the relationship between individual consciousness and the situations in which it is used and regard knowledge as an integral part of the context of the activities it develops.

Social learning. The interaction with other subjects of the school social environment is an important factor influencing learning itself. The participation of individuals in different social communities provides cognitive tools that help the learning process.

Distributive learning. This type of learning is associated with both the situational and the social nature of knowledge, where the individuals undertake to cooperate in the learning activities using their own resources.

A. Bandura [1977] regards the direct following of a model as a priority factor determining human behavior, which he calls "learning by observation." According to him, this way of studying includes four phases: attention, memory, reproduction and motivation. Learning through observation underlies the formation of basic professional skills which could not be subject to algorithmic or theoretical absorption.

Subject, objectives, purpose of the study

The main subject of the study is to assess the impact of the additional elective preparation in chemistry and the organized lecture-based and individual student work – how they can raise the level of professional student training. 39 first-year medical students participated in the study. They took part in an optional, supplementary module in chemistry called "Chemical factors in the natural and working environment" during the academic year 2012/2013.

The aim of the study was to establish how the implementation of different forms of contextual learning increases the level of the basic skills of medical students. To achieve the formulated objective, the following tasks were set:

Conducting an optional module in chemistry with emphasis on the contextual training of the students.

Development of questioning methods for research of the training that was implemented.

Performing surveys with the students.

Analysis of the obtained results. Presentation of the results.

Methodology of the study

The methodology of this study is based on the understanding that the contextual approach to the training of medical students in chemistry will contribute to the enrichment and development of their basic practical skills in medicine.

In order to perform the survey the following methods were used: observation, inquiry, and participation of the students in the practical application of contextual learning.

The monitoring includes: field study of water and assessment of its ecological status; monitoring the work of a team of doctors and chemists at the Regional State institution controlling the state of the natural and working environments, and the factors influencing environmental pollution; field introduction to new methods of ecological sanitation.

Through a survey, we studied how far contextual learning affects the development, promotion and formation of lasting professional competencies in the medical students. The students participating in the survey were asked to assess the formation of their basic skills and competencies. Two questionnaires were compiled and used for the purposes of the study - one before and one after the optional course in chemistry. The skills that were observed were directly related to contextual learning , such as: 1) the ability to work in a laboratory and to perform analysis of laboratory results , 2) communication skills, 3) the ability to distinguish the best practice, 4) the ability to self-organize activities , 5) the ability to work in a team, 6) the ability to think and take action in a professional manner 7) the ability to use non-traditional methods, 8) the ability to offer creative ideas and describe ways of fulfilling them in practice - the ability to understand the situation and analyze the problem.

Contextual learning requires that the professional pedagogical activity of the participants in the training take place in a continuous interaction between teacher and student, with continuous reference to the theoretical foundations of education.

Results of the research

Thanks to the survey, information was collected on the manner in which students describe and rank (on a scale of 1 to 10) the skills they have acquired as a result of the training.

1. In response to the question “How do you assess your skills in the laboratory?” (Fig. 01), students classified their skills as poor (maximum results in ratings 3 and 4) at the beginning of the training and relatively high (estimates 7, 8, 9) at the end.

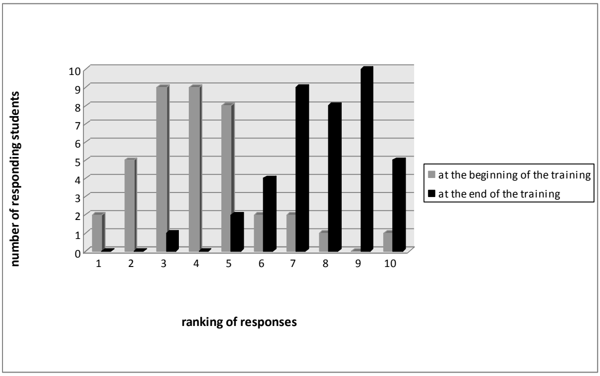

Fig. 01.

2. The responses of the students to the question "Do you know how to analyze laboratory results?" (Fig. 02) were similar to the way they answered the preceding question. The implication is that they are not yet able to distinguish clearly the mastery of certain chemical laboratory skills and the ability to interpret and analyze the results.

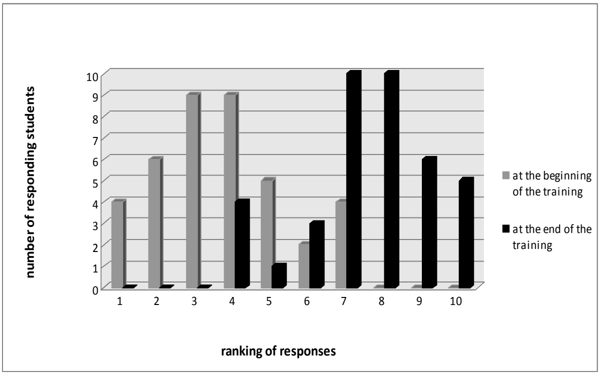

Fig. 02.

3. For the question "Have you developed your communication skills during training?"(Fig. 03), the dynamics of the frequency distribution of the students' self-assessment at the beginning of training and at the end show an increase in the students' confidence in their ability to communicate.

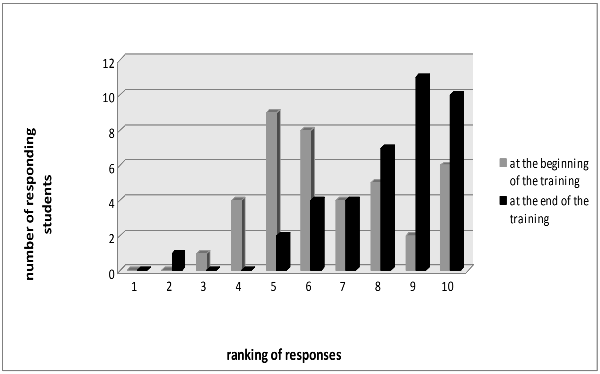

Fig. 03.

4. The question "Do you know how to distinguish a good practice?"(Fig. 04) received similar responses as questions 1 and 2. The conclusion again is that the students are not yet able to distinguish clearly the mastery of certain practical laboratory skills and the ability to interpret and analyze the results.

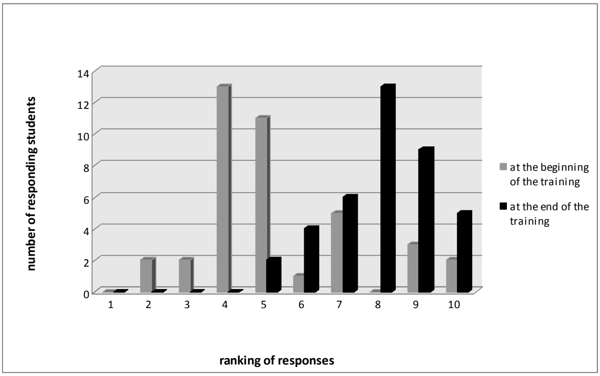

Fig. 04.

5. When analyzing the issue of "the skills of self-organization of the activity "(Fig. 05), we can see that the dynamics of the ranking before the training is logarithmical, while after the training it is almost linear. Such results can mean that there is increased internal self-assessment of the skills of the students for self-organization during the learning process, which would have a positive impact on their overall development as future physicians.

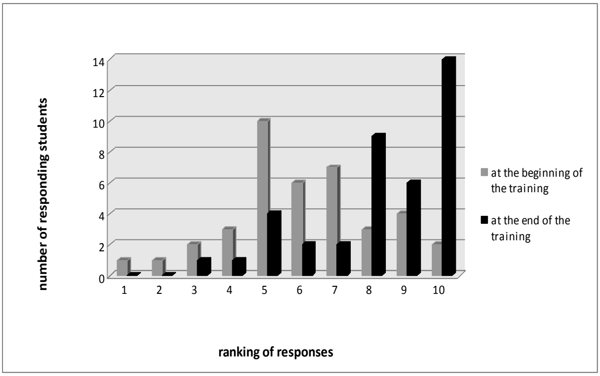

Fig. 05.

6. Regarding the question “Have you developed your ability to work in a team?” (Fig. 06), the dynamics of the frequency distribution of the self-assessment of the students at the beginning of the training and at the end show the increase of their confidence in their ability to work in a team, which is indicative of the readiness of the students to express an opinion, discuss it and defend it before the team.

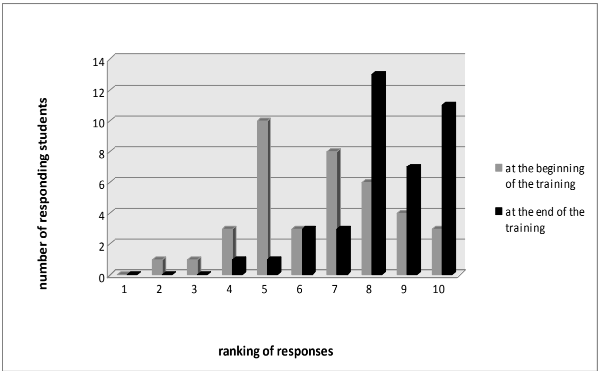

Fig. 06.

7. The dynamics of the frequency distribution of self-assessment in terms of the students’ ability for professional thinking and action (Fig. 07) show the increase in the general level of their reflexivity in the course of practical training. This result testifies to the increase in sensitivity and the professional competence of the students.

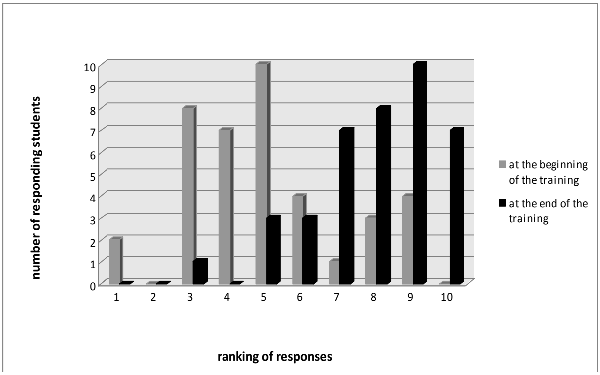

Fig. 07.

8. The question concerning the "unconventional skills of the students" (Fig. 08) was answered more hesitantly with similar results before and after the training. However, for the most part the students' confidence appears to have increased following the training. The fluctuating results can be interpreted as a consequence of the fact that freshmen do not have enough experience with "traditional" methods in order to make judgments about other, more innovative methods.

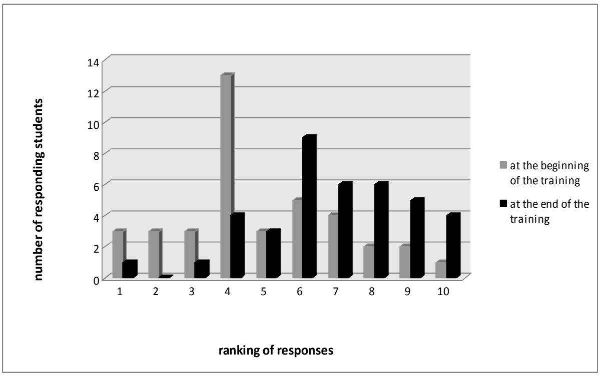

Fig.08.

9. The frequency distribution of the self-assessment of "the students' ability to offer creative ideas and descriptions of ways to fulfill them" (Fig. 09) shows an increase of about three or four points, which indicates high receptiveness to the possibility of implementing an idea creatively and looking for ways to make it come to fruition.

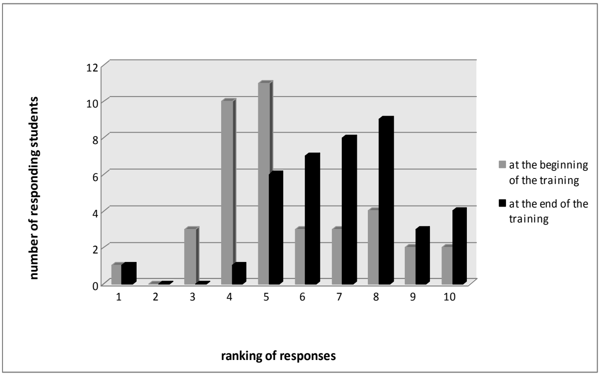

Fig. 09.

10. The answers to the last question concerning 'the skills to understand the situation and analyze the problem "(Fig. 10) showed that the frequency distribution of the self-assessment of students at the end of training was significantly elevated compared with the baseline. This result indicates a relatively increased professional confidence, and hence an increased motivation for activity on the part of the students.

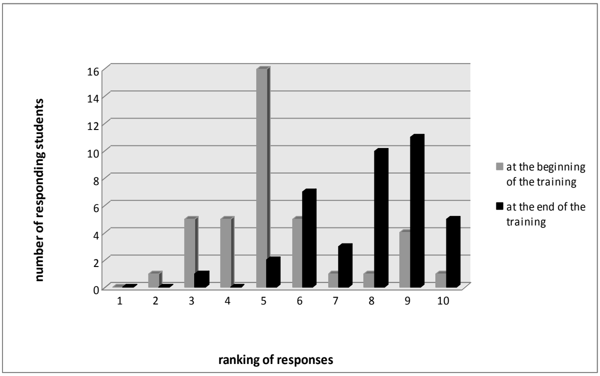

Fig. 10.

The analysis of the results shows that in certain professional fields some of the important skills can be acquired through contextual learning which includes the building of skills and developing of the personality (teamwork, communication, self-organization, analysis of the problem, etc.), as well as professional skills (analysis of laboratory results, distinguishing of best practice, professional thinking and action, creativity, unconventional work, etc.). Theoretical knowledge in academic training is no longer a sufficient basis for the development of the professional competence of the future specialists.

In conclusion: The results of the survey show that students appreciate the necessity for this type of training in their development as professionals. The mastery of theoretical knowledge and contextual learning are two equivalent sides of the modern academic process. Without their organic interrelationship, it would not be possible to provide high quality professional training and competence [Petrova & Stoykova, 2011, p.88].

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DESCRIPTION OF PHYSICAL PRINCIPLES IN THE WRITTEN WORKS OF MEDICAL STUDENTS

Eva Kralova

The context and purpose of the framework

The role of medical devices in healthcare is essential. The diversity and innovativeness of this sector contribute significantly to enhance the quality and efficacy of healthcare.

At the present, a high number of physical equipments is used for the medical purposes in research, prevention, diagnostics and therapy. Physicians need to receive additional information about patient health status by means of physical laboratory analysis. Using them they can measure and evaluate quantities, which are not detectable by human senses. They are useful also in special cases, for example when it is necessary to evaluate space and time dynamics of given biological process and its relation to external environment. The result of laboratory examination should confirm or exclude physician´s diagnostic hypothesis. Subsequent effective therapy is a result of complex and right diagnostics.

For the health protection of the patient and the staff all medical equipments must be in accordance with the relevant technical and hygienic norms. The examination conditions must be established to ensure reproducibility of measurement results. Therefore the physicians and health service staff have to be acquired with technical abilities of equipment and physical principle of given diagnostic method. Their technical knowledge and skills in correct operation of devices become very necessary.

Thus it is very important that medical students should be acknowledged with basic technical properties based on physical principles and measurement methods already during undergraduate studies. They acquire necessary knowledge and skills on the beginning of their education during the courses medical physics and biophysics, which can be used later in professional practice.

Teachers of medical physics and biophysics at Faculty of Medicine of Comenius University in Bratislava continuously pay attention to updating syllabus of these teaching subjects in accordance with the progress of science and the needs of medical practice. On the contrary, it is still necessary to explain and argue the medical community, management of faculty and students about significance of physical knowledge for both medical students and medical professionals. Among others in the 1st year of medical study the students are obliged to submit semestral project from medical physics and biophysics to become familiar with the physical principles of the modern diagnostic and therapeutic methods, technique and devices. (Kralova, 2012) Based on this fact it was also assumed that physical/biophysical aspects should be described in all types of their written works, including diploma theses. Confirmation of this hypothesis could help us to underline the important role of physically oriented teaching subjects as supporting subjects in medical curriculum.

Methods

We realized contentual analysis of :
- representative sample of 63 semestral projects from medical physics and biophysics submitted by 1st year medical students in acad. year 2011/2012 divided according description of diagnostic or therapeutic method based on given physical/biophysical field,
- representative sample of 100 diploma theses submitted in 2012 at Comenius University in Bratislava by students of general medicine from the point of view of medical physics and biophysics and their medical applications. This analysis has been possible starting from acad. year 2011/2012 thanks to the electronic publication of final theses in the central Slovak database. (Central register of final theses, 2014).

Results

Contentual analysis of semestral projects showed the most frequent topics: optics 4,1/9,6 %, biosignals 11/8,20 % and modern diagnostic/therapeutic methods 13,7/16,40 % (principles of radiodiagnostical, ultrasonic, thermographic, extra-corporeal lithotripsy, magnetic resonance imaging, positron emission tomography, laser, osteodensitometry devices). Increasing tendency was observed in percentage of semestral projects describing modern technologies in medicine comparing with the past. (Fig. 01)

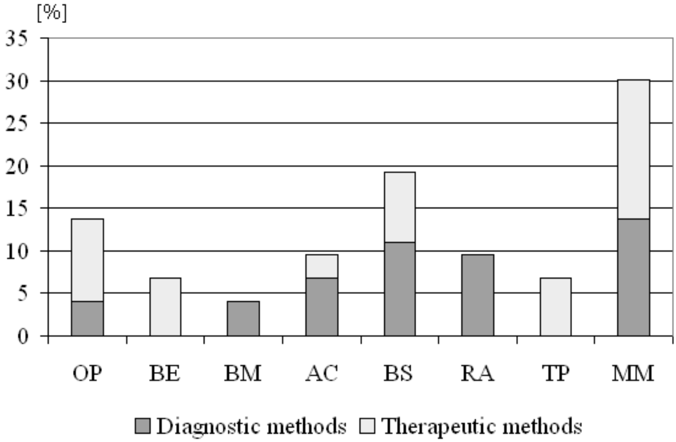

Fig. 01. Percentage of semestral projects focused on diagnostic or therapeutic methods based on given physical/biophysical principle (acad. year 2011/2012) [Kralova, 2012].

Legend: OP (optics), BE (bioenergetics), BM (biomechanics), AC (acoustics), BS (biosignals), RA (radioactivity), TP (transport processes), MM (modern D/T methods)

We have observed that the most part of diploma theses contained description of modern diagnostic and therapeutic methods based on physical/biophysical principle and their application in different medical disciplines (dental medicine, paediatrics, neurology, psychiatry, urology, internal medicine, pneumology and phthisiology, radiadiagnostics, radiotherapy, gynaecology and obstetrics, anaesthesiology, clinical biochemistry, orthopaedics, otorhinolaryngology, ophthalmology, haematology and transfusiology, dermatovenerology, general and plastic surgery, court medicine, pathological anatomy, nuclear medicine). Widely used imaging methods have been dominating: ultrasound imaging, magnetic resonance imaging, image-guided therapies using ultrasound and magnetic resonance imaging, image guided radiation therapy, diagnostic and therapeutic applications of light and lasers, X-ray imaging, digital X-ray imaging, image processing, mammography, medical applications of lasers and other non-ionizing radiation, optical methods and their application for cancer treatment and diagnostics, etc.

Results obtained by analysis of diploma thesis submitted in acad. year 2011/2012 show the current state in medical equipment in individual medical branches in Slovakia and purposes of its use. (Fig. 02)

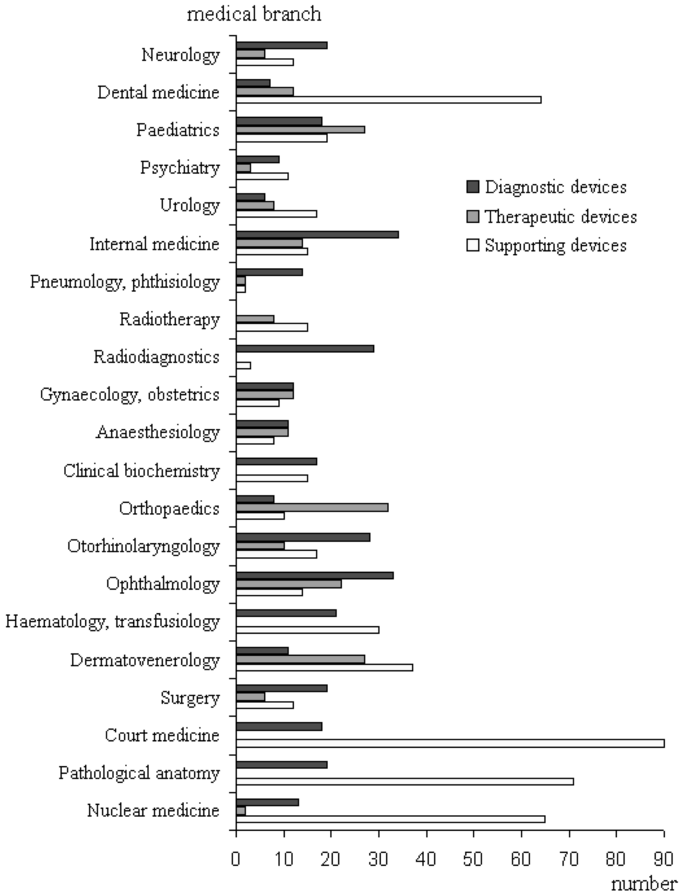

Fig. 02. Medical equipment categorized according to individual medical branches and purposes of its use.

Conclusions and implications

The main task of teaching medical physics and biophysics is to prepare students to understand those physical laws and principles that are applied in medicine. Students get knowledge on basic principles of methods and devices using in medical practice. It can be applied and improved in other medical sciences as physiology, pathophysiology, internal medicine, neurology, dermatovenerology, ophtalmology, otorhinolaryngology, internal medicine, pneumology and phtisiology and other related subjects that use methods and devices based on physical principles. In the same time the training of working with modern computer-based devices that nowadays is an inevitable part of basic equipment of any specialized medical workplace is important. [Kukurova, 2006)].

Frequent description of physical aspects and applications in medical student´s diploma theses reflects widespread using of modern diagnostic and therapeutic methods based on physical/ biophysical principles in medical practice today and thus our hypothesis was confirmed. It was also showed the key role of teaching subjects medical physics and biophysics in medical curriculum and their close relationship with another medical specialties. In the same time we obtained useful feedback for modification and innovation of physically oriented teaching subjects in medical study. Results of our analysis represent the base for innovation and updating of lectures and practical trainings on medical physics and biophysics according actual needs of health–care practice. [Balazsiova, 2012a,b]

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PREPARATION OF MEDICAL STUDENTS TO WORK IN CONDITIONS OF EHEALTH

Eva Kralova, Zuzana Balazsiova

The context and purpose of the framework

Medical faculties prepare health–care professionals for their successful entry to health–care practice. Good quality medical education requires also adequate digital competence, i.e. absolvents have to be prepared for their professional practice in conditions of eHealth. The level of information literacy of graduates is a key factor of their further progress in corresponding medical specialty. In this area has been identified deficiency both among medical students and health professionals. Our opinion shows that in extreme huge amount of expert information resources both groups need to be persistently oriented and trained. [Official Journal of EU, 2006]

University students should, according today requirements following from teaching process, to learn effective use of information resources, work with electronic information resources (EIR) and the search systems of technical and scientific information as soon as possible. For further study and practice in their chosen field of medicine it is necessary [Kralova, 2004; Peknikova, 2007)].

In this paper the level of digital competence and professional use of electronic information resources (EIR) on the basis of questionnaire is analyzed.

Methods

In our paper we present the results of two years survey of digital competence and using of professional information resources in the individual study of biophysics in 1st year of Faculty of Medicine Comenius University in Bratislava (FMCU), which illustrate their level of theoretical and practical preparedness for effective use of ICT. In each academic year 80 anonymous questionnaires were distributed.

Results

Respondents evaluated the level of their own digital competence – familiarity with the program MS Office and Internet, evaluated the use of EIR in individual study, benefits of Internet information resources, the use of conventional and professional internet information resources.

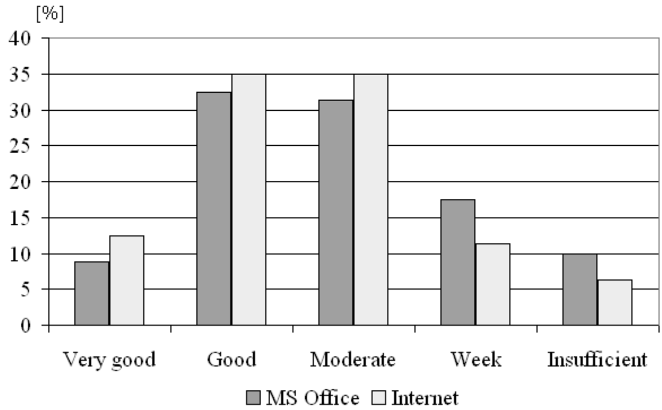

Fig. 01. Evaluation of the level of own digital competence by medical students.

Respondents evaluated in the survey their own practical skills in work with programme MS Office and searching information in Internet as follows: 41,3/47,5 % good to very good, 31,3/35 % moderate and week to insufficient 27,4/17,5 %. (Fig. 01)

Knowledge in the use of package MS Office and Internet for searching of professional information evaluated 41,3/47,5 % as good to very good, 31,3/35 % as moderate and as week to insufficient 27,4/17,5 % respondents.

To get information needed for the study 48% respondents preferred Internet over printed resources and the necessary information there was found by 9.2% always, 14.4% mostly, 33% sometimes, 26.6% rarely, and 11.9% almost never.

The most significant advantages of Internet information resources according to respondents are: quick search (60.0%), timeliness (76.3%), without charge (21.3%, the ability to search text strings (21.3%), links to other related information resources (25.0%), ecology (16.3%), multimediality (15.0%), others (1.3%).

The survey also showed that respondents prefer universal search engines (Google, Yahoo) 81,3% over professional EIR, which may be related to insufficient knowledge of physical and medical terminology in a foreign language (mainly in English). (Fig. 02)

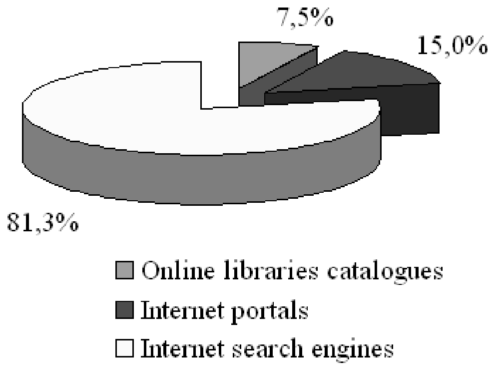

Fig. 02. Resources of relevant information obtained from Internet.

We asked few simple questions concerning electronization of health-care, e. g.: Have you encountered the term (Trnka, 2010):
- eHealth (40 % yes, 60 % no)
- standards for medical informatics (8 % yes, 92 % no)
- health–care information system (59 % yes, 41 % no).

Conclusions and implications

Based on these results the FMCU included into curricula of general medicine and dentistry new optional teaching subjects, with the aim to create better conditions for preparation of absolvents of medicine working in electronic health–care (principles of electronic health–care – eHealth, telemedicine, standardized medical terminology for dentistry). These teaching subjects represent novelty in medical study in Slovakia. [Kralova, 2012]

Survey of digital competence and readiness of medical students to work with electronic resources starting from beginning of the study pointed on existing reserves and the need to intensively develop their digital competence especially in the teaching of sciences. This deficiency could be compensated partially by application of project teaching and learning in the frame of biophysics in the 1st year of medical study.

First year medical students (general medicine and dentistry) demonstrated only a basic knowledge of the use of ICT in their written works, they were created in a text editor with simple formatting. Their knowledge and skills in creating tables, working with images, using tools MS Excel (statistics, tables, graphs) and Power Point were insufficient.

It follows that, during the undergraduate medical study it is necessary to further develop digital competence in teaching several courses. They are compulsory (biophysics, physiology, epidemiology, pharmacology, radiology, diploma seminar and others) and compulsory/optional elective courses (principles of e-Health, telemedicine, standardized medical terminology). Both professional terminology and foreign languages should also be studied and systematically completed.

Results of survey also highlighted the need to systematically educate and orient students to obtain professional information from the EIR, where they can find quality and relevant information for further study and career development.

Important source of technical and scientific information are bibliographic and full-text databases, electronic archives of magazines, web portals of health and medicine, as well as educational portal of medical and health care faculties and schools in the Czech Republic and Slovak Republic MEFANET [http://portal.fmed.uniba.sk/]. Wide range of freely available and licensed EIR like Medline, Web of Knowledge, SCOPUS, EBSCOhost, ProQuest and guides for searching information can be found on the website of Academic Library Faculty of Medicine [Kralova, 2013] (Fig. 03).

EIR are available through the fixed computer network of IP addresses of Faculty of Medicine or by remote access. They are relevant sources for finding the latest information for coursework, semestral projects, student scientific and professional activities, respectively final thesis.

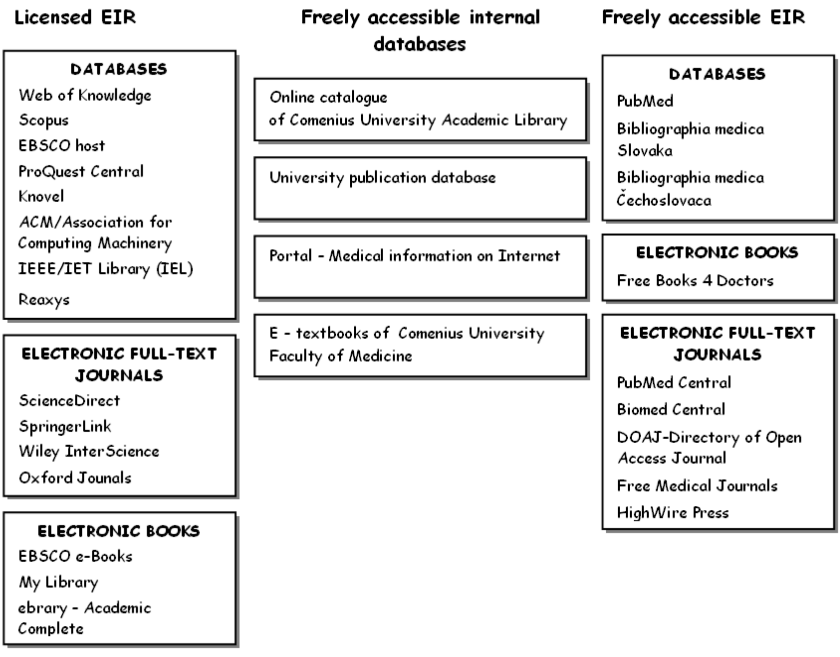

Fig. 03. Electronic information resources.

Simultaneously the grant project KEGA of Ministry of Education, Science, Research and Sport of SR № 052UK-4/2013 „Project of post-graduate education for university teachers and other professionals in the setting of health care enterprise (eHealth)“ is solved. The aim of the project is to itemize, prepare and realize in the target group of health professionals such conditions, so that they will be encouraged to induct their IT knowledge and skills into the profile of a graduate of medical or health care faculties.

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Textbooks in Science Education at all Levels of Education

THE EXTENT OF USE OF TEXTBOOKS AMONG CZECH STUDENTS

Hana Cídlová

Introduction

At the time of computers, internet and e-learning, it is becoming an important question which form of learning materials (printed, electronic) is better for given group of pupils or students (which is better to achieve better learning outcomes, which form prefer the pupils/students themselves). The authors of this research tried to find the answer to the second of these questions, namely for a group of university students of the field of study chemistry teaching in the first year of their study. Moreover, as it is known that the skill of Czech students to learn from textbooks is decreasing and that many of them do not use textbooks unless they are forced to, the authors wanted to know how often the students use their textbooks.

Methods and respondents

The research used two independent questionnaires and two electronic statistics that monitored the access of students to electronic study materials. Both questionnaires and electronic statistics were closely associated with study materials of mandatory courses for the field of study chemistry teaching at Masaryk University (General Chemistry, Recapitulation of Inorganic Chemistry Nomenclature).

Questionnaire I was answered by the first grade students (field of study chemistry teaching) of two schools: Faculty of Education, Masaryk University (MU) and one other Czech university after completing the course General Chemistry. Two slightly different modifications of the questionnaire for both schools were used (Tab. 02). This research work analyses only the answer to the question which form of study material for General Chemistry courses would the students prefer (Tab. 02).

Questionnaire II was answered by the first grade students of PdF MU after completion the course Recapitulation of Inorganic Chemistry Nomenclature. For the question analyzed in this work see Tab. 3.

In addition, electronic records of accesses to study materials were analyzed: statistics I (Elportál : Statistiky přístupu): - approaches to online textbook of nomenclature of inorganic chemistry [Cídlová and Musilová, 2009], statistics II - approaches to online exercises on nomenclature of inorganic chemistry. The results of electronic monitoring were compared to the answers of respondents to the questionnaire II. For numbers of respondents or users counted by electronic statistics see tab. 01. By means of statistics I, it was not possible to determine the number of people precisely because the textbook was accessible to anyone and it was impossible to identify the user. On the contrary, the exercises were accessible only to MU students and statistics II recorded among other data also identity of each user.

Tab. 01. Numbers of respondents for individual research tools.

Research tool	Numbers of respondents
Questionnaire No. I a) MU, b) the other Czech university	a) 42 b) 34
Questionnaire No. II	34
Electronic statistics I (textbook)	≥ 58
Electronic statistics II (exercises)	58

Results and discussion

Questionnaire I: The questionnaire was larger. Here is only the answer to its relevant part (tab. 02). The results are analyzed in fig. 01. The questionnaire had two modifications, because the students of MU use so called Informational System of Masaryk University (IS MU) but the other respondents do not. The question for MU students (tab. 02 - italics) was focused on application of IS MU, while the analogous question for the other university students (tab. 02 - gray colour) was more general.

Tab. 02. Questionnaire I. Italics - MU students, gray colour - students of the other university.

Which form of university study material for the course General Chemistry would you prefer? You can choose more than one possibility:

a) printed form
b) electronic form available *only by means of IS MU and only to students of a given course* (only to students of my university)
c) a book containing CD with version for printing
d) www pages *at Elportál* (freely available at internet) with version for printing
e) a book containing CD with www pages
f) another possibility (write here, please):

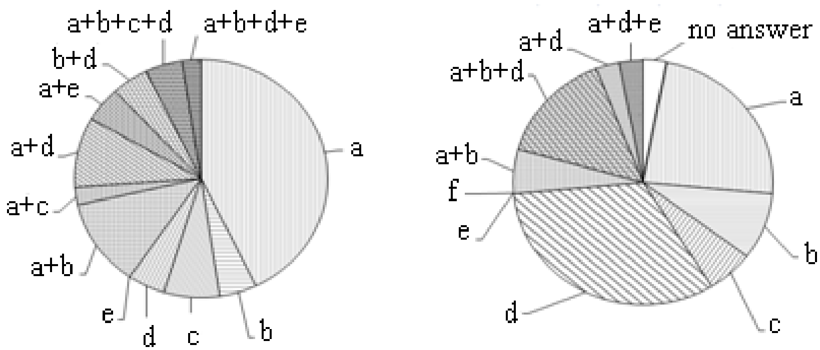

Fig. 01. Answers to questionnaire I. Left: students of MU. Right: students of the other university.

Questionnaire II was administrated to MU students after completion the course Recapitulation of Inorganic Chemistry Nomenclature immediately after the start of classes in the next semester. Only the relevant part of the questionnaire is discussed here (Tab. 03). For detailed results see Beranová and Cídlová [2012].

Tab. 03. Relevant part of questionnaire II. Numbers of the answers are written next to the squares. The last column contains numbers of questionnaires with no answer.

Which study materials and how often did you use to study inorganic chemistry nomenclature?

	once a week or often	twice a month	once a month	only during the exam period	never	no answer
online textbook *Chemical Nomenclature of Inorganic Chemistry* at Elportál MU	☐ 14	☐ 5	☐ 7	☐ 0	☐ 8	0
online exercises for the course *Recapitulation of Inorganic Chemistry Nomenclature*	☐ 5	☐ 6	☐ 11	☐ 2	☐ 9	1
a copy of printed textbook *Chemical Nomenclature of Inorganic Chemistry*	☐ 8	☐ 3	☐ 6	☐ 2	☐ 14	1
your own notes from lectures and seminar	☐ 20	☐ 6	☐ 4	☐ 0	☐ 4	0
grammar school textbooks	☐ 2	☐ 8	☐ 2	☐ 7	☐ 14	1
another possibility (write here, please):						34

The results of questionnaire II are quite surprising. Most of the respondents completed the subject Recapitulation of Inorganic Chemistry Nomenclature successfully. The answers of respondents, however, disagree with the information obtained from electronic statistics. Discrepancies are evident especially for textbook [Cídlová, et al., 2009] (statistics I). Reading the textbook, the students had no idea that they are monitored electronically. According to the data in tab. 3, 14 students claim that they used textbook [Cídlová, et al., 2009] once a week or more often. The total number of visitors according to the electronic statistics I from March 2011 to February 2012 was, however, only 9 (Elportál : Statistiky přístupu). It is obvious that respondents (students) overestimated their study effort (probably they wanted the teacher to like the answers).

Electronic information about the use of exercises approximately agrees with results of questionnaire II, probably because students know that the approaches to the exercises can be monitored and it is possible to identify individual students.

Electronic statistics I (number of accesses to textbook) and statistics II (number of accesses to exercises): Textbook of nomenclature rules (Cídlová, et al., 2009) prepared according to Musilová and Peňázová (2000) was published on Elportál at the end of December 2009. The exercises prepared also according to Musilová, et al. (2000) were published gradually form March 2011 to February 2012.

The vast majority of approaches (585) were in 2010. After the exercises were published (year 2011), the number of visitors dropped to only 9 (!). The low number of approaches can be partly explained by the fact that students use their grammar school textbooks and a considerable part of them (confirmed by the teacher) used a photocopy of the original printed textbook (Musilová, et al., 2000) - see tab. 3. However, this does not explain the relatively large number of visitors in 2010.

The exercises were available to 58 students (those who were subscribed to the course Recapitulation of Inorganic Chemistry Nomenclature). The number of exercises was 75. If every student would once open one exercise, it would mean a total of 4 350 approaches to exercises. According to statistics II, during the autumn 2011, when the course took place, there were only 183 approaches, which means 4.2 % of the estimated 4 350 accesses. This means that students nearly did not work with the exercises, too.

In the years 2013 and 2014 the number of accesses to the electronic textbook increased to 300-400 per year, maybe because the teacher stated solving of the exercises as one of the duties to receive a credit for the subject Recapitulation of Inorganic Chemistry Nomenclature. Against this hypothesis might refer the fact, that although till July 2014 total number of accesses to the textbook was 1351, only 10 of them are authorised accesses of students of Masaryk University.

Comparison of results obtained by different methods: According to questionnaire I the respondents the most often chose answer printed material or a freely accessible publication on the internet in the form of www pages, with version for printing. Students also chose different combinations of options. Nearly all the answers asked either printed form of study material or electronic form with version for printing.

Questionnaire II revealed that students use electronic materials more often than printed ones and that they used the textbook [Cídlová, et al., 2009] approximately as often as the electronic exercises. This is in contradiction with electronic statistics, especially data about textbook (the students did not know that their approaches are electronically monitored).

Conclusions and implications

For the course General Chemistry, both groups of respondents preferred printed study material or freely accessible websites with a version for printing. For the subject Recapitulation of Inorganic Chemistry Nomenclature, according to the questionnaire II, electronic exercises in combination with the students` notes are used more often than printed study materials. By comparison of electronic statistics and answers to the questionnaire it was shown that students can answer the questionnaire quite falsely. I addition, the results of statistics I support the idea that even college students in the first year of study work more “for credits” than “for knowledge”.

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THE INFLUENCE OF POLITICAL CHANGES AND CHANGES IN THE EDUCATIONAL SYSTEM ON MOTIVATIONAL TEXTS ABOUT HISTORY OF CHEMISTRY IN CZECH CHEMISTRY TEXTBOOKS

Hana Cídlová, Petra Křivánková

Introduction

History of chemistry belongs to significant motivational tools within chemistry education [Budiš et al. 1996, Solaz-Portoles 2010, Šíba & Klímová 2011]. Moreover, it provides an opportunity how to explain some theories and models for science education, including chemistry [Solaz-Portoles 2010, Seker, H. & Guney, B. G. 2012]. The selection of mentions about history must meet current requirements for education, which are influenced (among other things) not only by the educational system but also by the current political situation in the country. Chemical education is currently faced with a variety of phenomena of modern times. But, as Held [2010] notes about Slovak education: "in the name of modernization, major scientists, chemical discoveries and the inherent genesis of chemical concepts disappeared from content of chemical education".

As the Czech Republic underwent several important political changes and also curriculum changes, the authors of this text decided to find out how these changes affected motivational texts about history of chemistry in Czech chemistry textbooks for lower secondary schools.

The second aim was to find out, whether these changes resulted into better motivational function of mentions about history of chemistry or not. The authors of this research focused on lower secondary school chemistry education.

Methods

The first method of the research was directed content analysis of textbooks. The authors of this text studied all chemistry textbooks for lower secondary schools that were issued on the territory of today's Czech Republic from 1945 till today (i.e. 48 textbooks). Only the first edition of each textbook was studied. Total time studied (1945 – 2014) was divided into 4 periods according to important political or educational landmarks: 1945 – 1968, 1969 – 1989, 1990 – 2004 and 2005 – 2014. All mentions about history of chemistry were listed. The number of texts on the history of chemistry listed within this part of the research was 825.

Afterwards, the authors interviewed 6 respondents in order to propose which properties of the mentions might be responsible for their motivational function. According to the results of the interviews, the authors suggested different types of classification of the mentions.

The last part of the research used questionnaire. It contained 20 text items chosen from the list of 825 mentions about history of chemistry. The authors tried to prepare the set of texts to be as diverse as possible (in terms of the classifications that had been prepared before). One text sample was an extract from belles-lettres [Jirotka, 1943]. After each text sample, the questionnaire contained a five-point Likert scale [Rod, 2012] for the respondents to express how much they like or dislike the text. Below the scale there was an empty field in the questionnaire and the respondents were asked to write into this field why they like or dislike the text. The respondents were 50 pupils of lower secondary school (aged 14-16 years).

Results

After preparation of the list of texts about history of chemistry, the authors interviewed 6 respondents with the aim to find out the proposals of possibilities which properties of the texts might influence their motivational charge. The interviews resulted into the following ways of classification: subject matter containing the text about history, thematic focus of the text, length of the text (number of words), narrativity of the text (constructive information x engaging narration), language etc. (archaic language, artistic stylization ...).

As for the first aspect (subject matter), teachers can not choose the curriculum according to students` wishes. Therefore, this aspect was not studied in more detail.

Concerning the thematic focus of the mentions about history, the authors managed to classify all the 825 texts into 10 groups. The percentage of their occurrence in chemistry textbooks in different time periods is shown in table 01 (100 % is the total number of the mentions about history of chemistry in given period).

Tab.01. Percentage of the topics of the mentions about history of chemistry.

Topic / period	1945-1968	1969-1989	1990-2004	2005-2014
theories, laws, phenomena	33	41	26	27
obtaining substances (preparation, mining and manufacturing technology)	20	10	15	10
discovery of substances	15	12	13	6
history of names of substances	10	9	13	11
biographies of major scientists	6	0	5	8
historical use of substances	11	12	13	18
longer cross-thematic sections	1	2	1	1
fire	1	5	1	1
interesting unreal notes (legends, tales, fables)	0	4	1	2
interesting real notes (legends, tales, fables)	3	5	12	16

It can be seen from table 1 that the percentage of the topics changes with time. The changes are influenced by many factors including random, but systematic trends can also be traced:
- The largest attention is devoted to history of theories, laws and phenomena in all the periods. It could have been expected, as the authors of the textbooks try to use history also as a means of explanation (as was mentioned in the introduction of this text).
- In periods 1945-1968 and 1990-2004 there were nearly no interesting unreal notes (legends, tales or fables) in chemistry textbooks. One explanation might be that both the periods follow after „bad times“ (World War II, „totality“) and people therefore thought more realistically.
- The percentage of texts of interesting real notes increases since 1945 till now.
- There were no continuous texts about biographies of major scientists in chemistry textbooks in the period 1969-1989. It is possible to find some of them in titles to the figures, but never in continuous text. Were the authors afraid to write about scientists from „west“ countries and did this result to writing about nobody?
- The percentage of texts about discovery of substances decreases all the time, but the percentage of texts about historical use of substances increases all the time.

The third criterion of classification was the number of words of the text (Fig. 01).

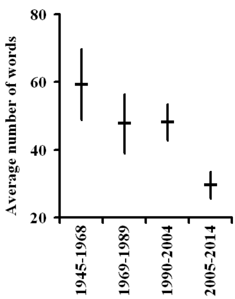

Fig. 01. The length of the topics of the mentions about history of chemistry.

It follows from the figure that the average length of the texts shortened since 1945. Maybe it is due to the fact that the reading skills of pupils decrease (that is why the authors expect that pupils would not read long texts). This idea is supported by the fact (result of another interview) that the authors of recent textbooks did not shorten the texts on purpose. They perceive the length of the texts (although they are much shorter than earlier) as „normal“. There might be also another explanation. As Held [2010] writes, the narrative history containing nice motivational details is lost from textbooks (the key moment might have been the period 1969-1989) and recent authors just do not know where to look for really interesting details from history of the science. As a result, they write short constructive texts.

Other important information was received by means of the questionnaire. Free answers of the pupils (explanations, why they liked or disliked particular text samples) were divided into groups with similar content and afterwards percentage for each group of explanations was calculated. The total (100 %) was number of negative or positive evaluations of text samples. The results are summarised in figure 02.

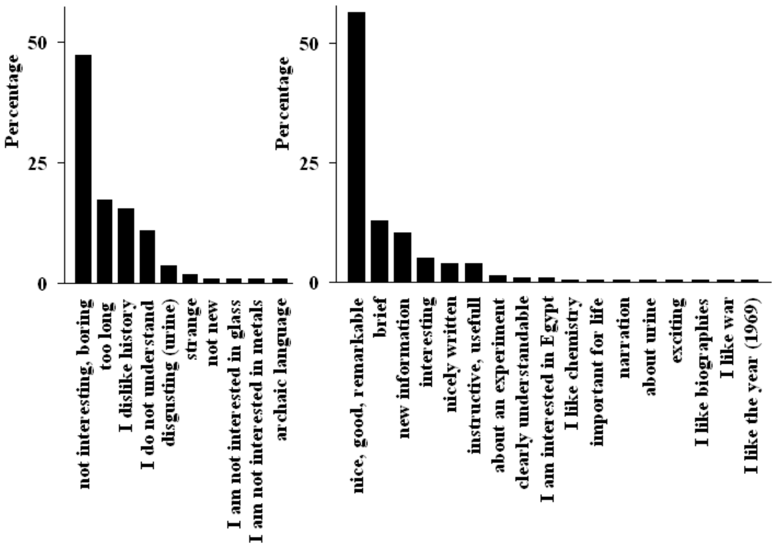

Fig. 02. Why pupils dislike (left) or like (right) the text.

It follows from it that the most important evaluation criterion for pupils is the length of the text (17 %: „I do not like the text, because it is too long”, 13 %: „I like the text, because it is brief.”). The limit was estimated from single answers of the pupils to be approximately 150-200 words. If we compare this number with results in figure 1, it is obvious that pupils perceive as interesting and motivating much longer texts then is the average. That means the authors do not have to shorten the texts on purpose. On the contrary, they might use the motivational texts to support the pupils to read more.

It is very important that the second more serious reason for “I do not like the text” was “I do not like history” (15 %). Therefore, the texts must not be similar to history textbooks, for instance they should not contain particular years if not necessary. By analysis of the list of texts about history of chemistry the authors have found that in period I (1945-1968) approximately 50 % of texts about history of chemistry contained particular years (centuries were not calculated). In period II (1969 – 1989) it was 25 %, in period III (1990 – 2004) it was 39 % and in the last period (2005-2014) it was 29 %.

As for narrativity and language of the texts, it was difficult to evaluate their influence, as answers of the pupils coincide with general answers „nice, good, remarkable, not interesting, boring,...”. The extract from Saturnin [Jirotka, 1943] was accepted mostly as boring (35 %).

Conclusions and implications

It has been found that the average length of texts about history of chemistry shortened since 1945 from approx. 59 words (years 1945-1968) to approx. 30 words (years 2005-2014). The length of the text proved to be the most important evaluation criterion for the pupils, but, on the other hand, the acceptable length of text is approximately 150-200 words).

The spectrum of topics of the texts changed since 1945, too. But, as revealed from the questionnaires, only few pupils write topic among reasons why they like or dislike the texts. The most frequent pupils` demand (not fulfilled in the textbooks) was that the texts should not be similar to history textbooks and they should not contain too much written year.

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THE ROLE OF THE TEXTBOOK IN THE DEVELOPMENT OF CONCEPTS - THE CASE OF GEOGRAPHY TEXTBOOKS

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Introduction

Despite many teaching aids introduced continuously into school practice a textbook is still one of the most popular tools to support teacher and student's work. This is confirmed by studies conducted both by teachers [Pingle 2010] and educators [Bedman, 2009, Graves 2001, Graves &Murphy 2000, Rodzoś & Wojtanowicz 2010].

A school textbook is used not only by the student, but as school practice shows, perhaps even more frequently by the teacher who finds in it model expressions, teaching tasks and means of motivation - e.g. illustrative material. For teachers a textbook is also the inspiration for teaching arrangements, sequencing of the terms or the proportion of certain types of exercises. For this reason, research on a textbook as a teaching aid is aimed at understanding its various aspects arising both from the point of view of the user-student, but also from the point of view of the user-teacher [Pingel, 2010].

To a large extent the content and structure of a textbook are determined by the objectives of education. Today, in many countries, including Poland, they undergo evolutionary, sometimes even revolutionary changes. At the same time we can observe the phenomenon of standardization of the education structure, which clearly occurred e.g. in the countries of Central and Eastern Europe (former socialist countries) that joined the EU in 2004, which had a significant impact on the formulated tasks and goals of education. Also, textbook authors are partially restricted by curriculum (Core Curriculum) and its structure. The curriculum affects the range of the content included in the textbook whereas the structure of the curriculum indicates particularly how individual differences, abilities and interests of students are taken into account.

The content, structure and language of a textbook significantly influence the formation of concepts and the way they are introduced, shaped and improved in the process of school education.

The role of the textbook in the formation of students' geographical concepts

The concept within the psychological meaning is a thought representation of a group of objects, phenomena, activities in which the significant features and characteristics common to a specific class are reflected [Wygotsky 1971, Kozielski 1966]. In the case of teaching geography it is connected with the ability that allows to describe reality and identify objects on Earth and explain the connections and dependencies. The process of distinguishing colloquial language (natural) from the language used in science takes place through the process of geographical education. The exact content of this concept and its range are determined through educational activities and thereby we submit to the definition of concepts, i.e. the creation of the real language of science. Therefore, the issue of the development of concepts is so important in the educational process as it allows learners to develop advanced forms of thinking, i.e. the ability to use symbolic material in a variety of mental operations.

The issue of geographical terms in the geography teaching in Poland was studied by J. Flis. Watching the chaos of concepts that occurred in geography textbooks, he compiled - School geographical dictionary (1977). In his work Terms and their formation in the teaching of geography in grammar school (1982) he dealt with the properties of concepts and their development during geography lessons in logical and didactic aspects.

A textbook plays an important role in the field of the development of concepts. Here you can include the detailed concept of education (educational program) stimulating and organizing students' activities aimed at the development of concepts. It refers to the detailed teaching proposals of introducing basic geographical concepts at different levels of education, as well as planned control of their understanding in operative and formal aspects. Generally, teachers only partially plan and partially improvise their teaching activities in the classroom. Therefore, well designed textbooks, which include the process of the development of concepts, corrected by the teacher having a regular contact with students seems to be the most effective method.

In view of literature, the approach of geography textbook authors in relation to the role of this agent in the correct format, and the usage of known terminology by the students in order to describe and explain the known reality , is very different. You can find both ,books in which there are only a verbal definition of the term (often a formal definition) as well as those in which the new concepts included in the textbook are not explained.

Methodology of Research

The essence of this research is to determine the forms and ways of functioning and placing geographical terms in school textbooks for lower secondary schools in Polish reformed school. Some geographical contents concerning Polish geography, included in The Core Curriculum for Primary and Secondary Schools [Journal of Laws, 2002] and in teachers' curricula as well as in selected textbooks for students of third year of lower secondary school were chosen to illustrate the aspect mentioned above . Four out of twelve textbooks for students of third year of lower secondary school ,approved for use by the Ministry of National Education in 1999-2002, were selected for the study. The analyzed sources have been developed by different author teams and published by four publishing houses, i.e. WSiP (A) - a company with a large range of publishing (formerly state-owned) and publishing houses of local range, which entered the market after 1989: Association of Polish Educators in Torun (B), M. Rożak Publishing House in Gdansk (C) and Zofia Dobkowska "Żak" Educational Publisher in Warsaw (D).

The main objective of the study was to:
- determine the number of geographical terms occurring in the core curriculum and in four selected geography textbooks in the field of Polish geography (for students of third year of lower secondary school) and to identify their category,
- become acquainted with different ways of introducing geographical terms in the analyzed textbooks,
- know the students' opinion on the teaching methods of geographical terms and methods of their acquisition.

The basic method of the implementation of the first and second objectives was analysis of documents, particularly one of its techniques, such as frequency analysis technique, which allowed the preparation of quantitative description of geographical names occurring in the texts and graphics. In pursuing the first objective, each geographical term was counted only once, regardless of whether it appeared in the examined textbooks once or several times. As a result an index of geographical terms was created ,which became the basis for various findings. The research also sought to determine ways of introducing these terms in the textbooks. The following quality indicators were adopte : using the featured fonts , explaining the meaning of the term and using the illustrative material (graphics) to explain the introduced terms.

The pilot research was aimed at understanding the practice in the field of studying and learning geographical concepts. It was conducted among the students of third year of lower secondary school, in those schools where students and teachers used geography textbooks which had been selected for analysis. In these studies a questionnaire which included open and closed questions was applied.

Results of Research

Of the total of 3638 selected terms included in the analyzed textbooks -71% (2587) of them are located in the text, 12% (426) in the graphics, and 17% (626) in the graphics and the text (Tab.01).

Among the analyzed textbooks the highest number of geographical terms was recorded in textbook A, and the smallest number in textbook C. In all textbooks unexplained concepts are dominant, partially due to their earlier introduction in year 1 and 2. The biggest number of explained terms in the text (Tz) was found in textbook B (32%) and the lowest number in textbook C (11.3%).

Tab. 01. The number and the form of presentation of geographical terms in textbooks for 3rd grade of lower secondary school (gymnasium).

Textbooks	Numer of pages	Total numer of terms	Form of presentation of geographical terms						
			Text				graphics		
			Total	Tz	TwTz	Tw	Total	Bg	BBg
A	224	1264	1140	198	11	35	221	124	97
B	219	1867	1386	48	166	147	464	273	191
C	189	970	829	59	208	63	211	141	70
D	198	1368	1160	41	91	231	369	208	161

Legend : Tw- terms marked in boldface, Tz - explained terms not in boldface , TwTz - terms in boldface and explained, Bg - terms occurring only in graphics, BBg - terms occurring in graphics and text.

From the point of view of geographical education, a small number of terms explained with the use of graphic materials, appearing in the analyzed textbooks suggests that the authors are in favour of the introducing the terms according to the verbal concept. This concept is based on the perception of general expressions based on the information included in it. As the research on the perception of concepts [Wygotsky, 1971, 1978, Bruner 1978] shows, this approach is not conducive to the process of abstraction, often a text in which general expressions appear, is not fully understood by students (especially when there is no reference to the photographs, the chart,the graphs, etc.). A well-run process of developing concepts, consisting of various student's activities and observations made by him e.g.: using illustrations, graphs, schematic drawings, computer animations as well as doing various exercises in which this concept appears, brings better educational effects in the field of remembering, understanding and applying the learned geographical terminology. Illustrative material supports visualization process of things and objects, and stimulates motivation and interest in learned information. Unfortunately, in the analyzed textbooks this concept of introducing scientific terms was less used by the authors. Most often this approach was applied by the authors of textbooks B and D, who in that way explained about 25% of all concepts included in the textbook.

It is interesting, to what extend the authors placed in their textbooks the concepts from the Core Curriculum for lower secondary school and from teachers' curricula. The authors of textbook B included the biggest number of geographical terms : 4 out of 6 terms from the Core Curriculum [Journal of Law, 2002] and 79 out of 104 concepts from the author's curriculum. 19 terms from the curriculum are explained, and 36 are highlighted in boldface. An author of textbook A placed one term from the Core Curriculum and 46 from the curriculum, including 36 which are explained (26 graphically, 10 textually). Authors of textbooks C and D did not placed any terms from the Core Curriculum. Textbook C contains 82 terms out of 114 included in the author's curriculum, including 43 which are explained and 47 which are in boldface. In textbook D, 11 out of 23 terms from the curriculum were placed, including 4 explained terms and

6 highlighted in boldface.

The presented analysis shows that the authors of the surveyed textbooks not only preferred a different approach to ways of presenting geographical terms, but also clearly revealed the difference in the number of used terms. Therefore, analysis was carried in terms of the frequency of occurrence of these concepts in 4 textbooks. Listed terms (3638) were divided into three groups according to the following criteria: the terms found in all textbooks (4), the terms appearing in three textbooks (3) and the terms that occurred only in the two textbooks (2).

Tab. 02. The number and the way of presentation of geographical terms in textbooks for 3rd grade of lower secondary school according to their frequency of occurrence.

Number (group) of textbooks in which the terms are repeated	Number of terms		Geographical terms						
	Total	%	Highlighted in boldface				Explained		
			total	Tw %	including TwTz	TwTz (%)	total	TwTz	Tz (%)
4	190	5,2	125	65,7	82	65,6	99	52	17
3	277	7,6	128	46,5	75	58,5	96	34,9	21
2	604	16,5	174	28,8	102	58,6	160	26,4	64

Legend: Tw-terms marked in boldface, Tz - explained terms not in boldface , TwTz - terms in boldface and explained.

Study of the frequency of occurrence of the same terms in various textbooks showed that only 190 (5.2%) terms, out of 3639, appear in four analyzed textbooks , 277 terms (7.6%) in three textbooks, 604 terms (16.5 %) in two textbooks and up to 2568 terms (70.5%) occur only in one textbook (Table 2). The data indicate ,among others that 70% of the terms which appeared in the analyzed textbooks can be considered as unnecessarily introduced for students of 3rd grade of lower secondary school.

While examining these 190 terms (which are repeated in all four textbooks) was observed that 125 (65.7%) of them are highlighted in boldface and 99 are explained, which of course should be viewed positively. Other low frequency terms generally have a much smaller percentage of explanations or highlighting (in boldface). A method of introducing new concepts in boldface is for a student a kind of additional information about the importance of these concepts in learning process. This is even more important because as the analysis shows, the number of terms included in textbooks is great. Also the form of presenting the introduced term influences students' motivation and the process of assimilation of its content.

In addition, it was found that in the analyzed sources subject-specific concepts, related to existing objects and observable objects and phenomena, represented 76.5% (2781). These included a group of terms related to the characteristics of the natural environment, the economic environment and cultural heritage of Poland (e.g. glacial valley, moraine, spit, cliff, heap, acid rain, city, factory). Abstract concepts represented 23.5% (857) of all terms. These are mainly the terms of the population geography, and social and economic geography of Poland (e.g. population growth, voivodeship, population density, vegetation period, demographic structure).

Considering practical aspect of the conducted research related to the development of concepts in the process of teaching geography, some surveys on learning geographical terms as well as on difficulties that go along with this process were carried among students of 3rd grade (89 people).

The collected data revealed students' difficulties in distinguishing geographical names from geographical terms. From the list of geographical names and terms included in a survey and related to the content of geography of Poland, only 34% of the students were able to distinguish the geographical term from the geographical name. This result indicates a problem in the process of teaching geographical terms and names at school. The fact of the excessive number of geographical names included in school textbooks was shown in the research conducted by Markowska [1953], Piskorz & Tracz [2002].

The surveyed students indicated that they usually check new learned geographical terms, insufficiently explained in the textbook, in other sources (Tab. 03). They pointed to written sources: encyclopedias, dictionaries, etc. -(40.3%) as the most common, and to a lesser extent the Internet (8.95%), which undoubtedly results from technical conditions of the accessibility to this source of information.

Tab. 03. Sources used by the students to understand the terms not explained in the geography textbook.

Sources of knowledge	Number of indications	%
encyclopedias	18	8,9
dictionaries	6	6,7
books	7	7,8
workbooks	5	5,6
Internet	8	20,2
teacher	4	4,5
parents	5	5,6
other sources	5	5,6

Finding out the students' opinion on methods used by teachers in order to check learned concept was significant for understanding the process of the development of geographical terms. According to the students, the teacher most often checks the knowledge of geographical terms in oral (46.7%) or written form (23.3%) - Tab. 04 and most often these are questions involving giving the definition of the term.

Tab.04. Checking the knowledge of geographical terms learned by students

Forms of checking (by teachers) the knowledge of geographical terms	Number of indications	%
oral form	36	46,7
written form	18	23,3
Exercises	2	2,5

The dominance of this kind of action, when it comes to checking the knowledge and the usage of the terms, is far from theoretical indications. The lack of didactic tasks ,allowing to solve different theoretical and practical situations does not affect the efficient development of the resource of geographical terms, and their usage by students .This is also confirmed by the exam results achieved by students in their final lower secondary school examinations in geography. The students had considerable difficulties with the tasks, in which knowledge of geographical terms was required to solve the presented problem [Tracz 2008, 2012].

Conclusions & Discussion

The analysis of geographical terms of Polish geography, included in four textbooks for 3rd grade students of lower secondary school, revealed authors' considerable flexibility in their implementation. It is probably a result of too general record of the content of education and achievements included in the Core Curriculum (2002). Therefore reviewers of textbooks should more carefully assess the geographical names included in them, in terms of their indispensability in the process of teaching geography at this level of education.

Methods of implementation of geographical terms in textbooks for presented educational level correspond with two current teaching concepts. According to one of them, the process of teaching geographical concept is mainly based on the use of the form of text, i.e. on verbal description and naming the concepts. Unfortunately, in the analyzed textbooks, this approach was dominant. The second concept indicates the need to use various visual material, which is the basis for abstraction and generalization, and the need for didactic tasks which allow to use them in solving practical and theoretical problems in the process of developing geographical terms.

This means that, despite the declared with the successive curricular reforms transfer of emphases from idiographic teaching to nomothetic and holistic teaching in school textbooks have not been fully reflected. An encyclopedic approach still dominates to teaching geographical concepts instead of a constructivist approach- functional learning. Therefore, in methodological books for teachers ,the guidance on the effective ways of developing concepts and the level of their acquisition by students in the constructivist approach is necessary.

Teachers draw attention to the need for far-reaching modernization ,both in terms of the content of the textbooks, as well as their design and graphics. This is the more urgent challenge due to the widespread application of new information and communication technologies. Analyzed textbooks, when it comes to methods of introducing geographical terms, were little prepared to cooperate with the new teaching aids ,e.g. the Internet. At the same time, it should be emphasized that the Internet as unlimited source of access to knowledge, is a major challenge for the process of development of geographical concepts.It results , among others, from the fact of the substantive correctness of the terms posted on the Internet, especially in the popular and generally available Wikipedia. It would be advisable to carry out research on the substantive correctness of geographical definitions posted there, especially these which are found in textbooks and curricula for teaching geography at lower secondary school. At the same time the Internet offers great possibility of using visual materials, graphics and animation to exemplify the characteristics of the analyzed concept, especially in the category of concrete concepts. In the case of teaching geography this visualization is significant for terms assimilated by students.

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Contents

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