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PROJECT-BASED EDUCATION IN SCIENCE EDUCATION: EMPIRICAL TEXTS

XV.

Martin Rusek

Karel Vojíř

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EDITORIAL

Dear participants of the conference Project-based Education in Science Education XV.,

Our conference celebrates 15th jubilee and it is at most pleasant that the number of participants is again greater. In this year, the focus on natural sciences is complete. Traditional participants representing chemistry and biology are completed with physics and geography educators. Also, the spectrum of the paper topics is broader. The original focus on project-based education and already established inquiry-based education is supplemented with other activating strategies of students' learning process guidance in both of practical and theoretical nature.

Strakonice, April 2018

Martin Rusek

(editor)

INFORMATION, DATA AND STATISTICAL LITERACY AS FOUNDATION STONES OF PROJECT-BASED EDUCATION

ŠORGO Andrej

Abstract

According to a study by the World Economic Forum, the three top in-demand skills in the year 2020 will be Complex Problem Solving, Critical Thinking and Creativity. All three skills can be successfully developed within carefully planned and conducted open-ended loosely-defined project work. In such projects, the teacher's role is coaching and mentorship, allowing students to address a problem, define project outcomes, and in a creative and critically open atmosphere, find methods leading to the final solution. However, development of these skills is limited and may not even apply when projects are too well defined and the major role of the students is to follow the teacher's guidance uncritically.

Inquiry, regarded as a process of seeking answers, should be an integral part of problem-based education. Through scaffolded inquiry, students can develop information literacy skills that can provide them with the ability to address a problem and to find, select and manage sources. Typically, information-literate students should recognize the signs of flawed sources and biased information. However, even if the best sources are collected, these are worthless if users are unable to understand, manipulate and synthesize data, skills which can be seen as constituting data and statistical literacy. All three literacies are interconnected and can be regarded as transferable skills applied not only in forthcoming projects but also as a lifelong strategy.

Key words

information literacy, data literacy, statistical literacy, project-based education

INTRODUCTION

"It is easier to move a graveyard than to change a curriculum." (Woodrow Wilson)

Nobody can be confident of predicting the future at the global, societal or personal levels. However, based on recent knowledge, we can be almost certain that the production of knowledge will continue at exponential rates, generating new technologies based on biotechnology, information and communication technology (ICT), artificial intelligence and robotics, a phenomenon that calls for new knowledge to understand these technologies and the skills to manipulate them.

Many predictions made in the past have come true; however, many of them can be recognized as ridiculous from a recent perspective. Digital worlds are no exception to the rule, and quotations such as these can readily be recognized as examples of missed prophecies:

- "I think there is a world market for maybe five computers." (*Thomas John Watson, IBM, 1943);*
- "There is no reason for any individual to have a computer in his home." (*Ken Olson, Digital Equipment Corporation, 1977);*
- "640K ought to be enough for anybody (*William ("Bill") H. Gates, Microsoft, 1981):*

By analogy, prediction of the number and components of the competences crucial for successful life in the future can be hazardous, which does not mean that such lists are meaningless.

It is fact, not opinion that a new time calls for the introduction and improvement of skills important for citizens. Based on a set of occasionally dubious predictors, many are preparing lists, collectively called '21st Century skills'. According to Tony Wagner (2008), a list of 21st Century Skills is constituted from the development of the following:

- critical thinking and problem solving;
- collaboration across networks and leading by influence;
- agility and adaptability;
- initiative and entrepreneurialism;
- effective oral and written communication;
- accessing and analysing information;
- curiosity and imagination.

The flexible nature of the importance of top skills can be inferred from comparing two lists of skills compiled by the World Economic Forum (2016) (Table 1).

Table 1: Lists of the most important skills compiled by the World Economic Forum

	2015	2020
1	Complex Problem Solving	Complex Problem Solving
2	Coordination with Others	Critical Thinking
3	People Management	Creativity
4	Critical Thinking	People Management
5	Negotiation	Coordinating with Others
6	Quality Control	Emotional Intelligence
7	Service Orientation	Judgment and Decision Making
8	Judgment and Decision Making	Service Orientation
9	Active Listening	Negotiation
10	Creativity	Cognitive Flexibility

However, in Wagner's words, "we have no idea how to teach or assess these skills." Starting from the position that learning by doing and practice is the only practical path for mastering skills, educators should provide challenging tasks that will not only attract students but also motivate them to achieve mastery. It remains an open-ended question whether adaptation of recent strategies will suffice, or whether new educational forms should be invented. Based on previous knowledge and experience, project-based education (Rusek & Dlabola, 2013) is a plausible option for both acquiring and improving the skills on both lists.

THE ROLE OF PROJECT-BASED EDUCATION IN THE DEVELOPMENT OF 21ST-CENTURY SKILLS

The delineation between project-based, problem-based, inquiry-based, discovery-based and other related styles of instruction is unclear. In the educational literature, these terms are used loosely and often in ways unrelated to the clarifications and examples provided in dictionaries, or to the understanding of the same terminology in related practices in other fields such as industry, entrepreneurship and the arts. For all these instructional strategies, it is common for them to be based on engagement of students and a student-centred approach in an arc from the no guidance approach, through minimal guidance, to structured scaffolding. According to the definition of Marx, Blumenfeld, Krajcik, & Soloway (1997, p.341), the project-based approach is described as follows:

> “Project-based science focuses on student-designed inquiry that is organized by investigations to answer driving questions, includes collaboration among learners and others, the use of new technology, and the creation of authentic artifacts that represent student understanding”.

Regardless of the name used, we can predict that well-defined projects where the major role of the students is to follow the teacher's guidance uncritically will have minimal or zero influence on the achievement of 21st-century skills. However, considerable influence can be expected from the application of carefully planned and conducted, open-ended and loosely-defined project work. In such projects, the teacher’s role is coaching and mentorship, and the role of the students is to address a problem, define the project outcome, and in a creative and critically open atmosphere, find methods leading to the final solution. This does not mean that defined projects should be abandoned or completely replaced by open-ended versions. The reason is that their role as predecessors of open-ended projects is precious. Through scaffolded guidance, students can learn basic principles of project planning and execution, in an arc from initial idea to the final product.

THE ROLE OF DIGITAL COMPETENCES IN PROJECT-BASED EDUCATION

Digital competence, digital literacy, ICT literacy and computer literacy are all terms being used synonymously and interchangeably, in response to attempts to define the capacity to operate with digital technologies. Undoubtedly, technologies based on ICT have already transformed our societies, for good or ill. The reason is that digital technologies not only replace and modernize older technologies, but also change society. As a response, European authorities have prepared a number of documents and initiatives, where digital competences are recognized as part of the survival kit of citizens (e.g. DigComp; Digcomp 2.1). It is not enough to recognize the importance of such competences; in addition, there must be a transformation of education in the direction of three key ICT related learning activities. Paraphrasing principles already used in environmental education and applied in technology and engineering education (Ploj Virtič & Šorgo, 2016), the first educational arena is to teach about technology, the second is to teach with technology, and the third is to teach for technology, leaving open the question of how to educate for jobs that did not exist at the time workers received their schooling (Illeris, 2008). Nowadays it is difficult to imagine any project that is not supported by or based on digital technology, which calls for a set of skills to apply them, if not to operate with them.

THE ROLE OF INQUIRY IN PROJECT-BASED EDUCATION

Based on older pedagogical theories such as Dewey's and learning by doing, all forms of project work should include inquiry. This may not be completely true for simple, well defined projects, where outcomes and standards for their assessment are known beforehand, but inquiry is obligatory in open-ended and vaguely-defined project-work. Inquiry in such contexts can be regarded as a process of seeking answers -- a process that should be, to a greater or lesser extent, scaffolded by instructors. Through scaffolded inquiry, students can develop the information literacy skills that can provide them with the ability to address a problem and to find, select and manage sources. Typically, the information-literate student should recognize signs of flawed sources and biased information. However, information literacy must be upgraded with data and statistical literacy. All three literacies are interconnected and can be regarded as transferable skills applied not only in the projects at hand but as a lifelong strategy, as well.

THE ROLE OF INFORMATION, DATA AND STATISTICAL LITERACY IN PROJECT-BASED EDUCATION

The internet has made it easier than ever to access information; however, recently it has emerged as a forum that is far from ideal in cases where evidence and logical reasoning (Thouless, 2011) are expected to govern providers of information and its users. In the DigComp frameworks, information literacy is recognized as an integrated part of digital competence for everybody. However, most references connect Information Literacy to Libraries as providing an intellectual framework for understanding, finding, evaluating and using information (ACRL, 2000). A comprehensive review of the different definitions of information literacy is provided by Boh Podgornik, Dolničar, Šorgo, & Bartol (2016). It is a commonplace that digital natives, given their heavy use of technology from an early age, are automatically information literate--which is far from the truth. As was recognized by Šorgo, Bartol, Dolničar, & Boh Podgornik (2017), only well-designed and purposeful courses are significant predictors of information literacy. ICT ownership (smart phones – stationary and mobile computers); ICT experience (usage on a scale from never, to a few times a day); Internet confidence (I feel comfortable when …); and ICT-rich courses (the number of courses where ICT was used in a student-active way), were all tested as possible descriptors of digital nativeness influencing information literacy. The findings revealed that the attributes of digital natives – ICT ownership, experience and confidence--did not correlate with information literacy; however, they did correlate among themselves, leading to the conclusion that society cannot rely on information literacy skills achieved through a disorganized and spontaneous process.

Nevertheless, even if the best sources are collected, they are worthless if readers are unable to understand, manipulate and synthesize data, abilities that can be regarded as constituting data and statistical literacy. In the words of Schield (2004),

> “The evaluation of information is a key element in information literacy, statistical literacy and data literacy. As such, all three literacies are inter-related. It is difficult to promote information literacy or data literacy without promoting statistical literacy. While their relative importance varies with one’s perspective, these three literacies are united in dealing with similar problems that face students in college. More attention is needed on how these three literacies relate and how they may be taught synergistically. All librarians are interested in information literacy; archivists and data librarians are interested in data literacy.

> Both should both consider teaching statistical literacy as a service to students who need to critically evaluate information in arguments."

The insufficiency of information literacy can be traced in the evolution of the Digital Competence Framework for Citizens in the section on information literacy. Differences can readily be recognized in the changes to corresponding frameworks from 2013 and 2016 (Pérez-Escoda, Fernández-Villavicencio, 2016) (Table 2).

Table 2: Differences in DigComp and DigComp 2 frameworks in the domain of information literacy.

	DigComp (2013)	DigComp 2 (2016)
	A Framework for Developing and Understanding Digital Competence in Europe.	The Digital Competence Framework for Citizens
1	Browsing, searching and filtering information.	Browsing, searching and filtering data, information and digital content.
2	Evaluating information.	Evaluating data, information and digital content.
3	Storing and retrieving information.	Managing data, information and digital content.

When talking about different kinds of literacy the first question to be answered is, 'What is data literacy?' The definition provided by Carlson, Fosmire, Miller, & Nelson (2011) goes as follows:

> "Data literacy involves understanding what data mean, including how to read graphs and charts appropriately, draw correct conclusions from data, and recognize when data are being used in misleading or inappropriate ways."

Nowadays, we are witness to numerous cases where data are being interpreted or misinterpreted in varying ways. Examples of such claims include our understanding of the presence of chemicals in food, or misunderstanding of the difference between danger and probability, and as a further example, a misreading of units contributed to the loss of the Mars probe.

A prime example of the importance of out-of-the-box data interpretation is the solution to the problem of armouring aircrafts created by Albert Wald. Wald's genius lay in reinterpretation of the damage to aircraft returning from bombing missions. The prevailing idea was that the positions most heavily damaged should be additionally armoured. He recognized that they lacked the ability to analyse damage to planes that failed to return. He concluded that only planes with non-lethal damage were returning. Therefore, he advised additional reinforcement to areas where the returning airplanes were untouched (Wainer, 1992).

Operationally, our conclusion can mean that during project-based education, students should collect and interpret either their own data or assigned data to find novel and creative solutions. Not to be forgotten is that important issues in data management are privacy, safety and intellectual property. However, these are of minor importance for school-based projects, and so are not discussed in this paper.

An upgrade to data literacy is statistical literacy. It can be defined thus (Wallman, 1993, in Ferligoj, 2015):

> “Statistical literacy is the ability to understand and critically evaluate statistical results that permeate our daily lives – coupled with the ability to appreciate the contribution that statistical thinking can make in public, and private, professional and personal decisions“.

And in the words of H.G. Wells (in Ferligoj, 2015), “Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.”

It remains an open question at what level someone should understand statistics, and from individual practice, it is known that even academically educated persons can have difficulty understanding even traditional statistics, not to mention its modern variant. Developing statistical literacy is probably one of the most difficult challenges in education, reflecting complexity at the content levels and lack of experiences with statistics of teachers. According to Watson, & Callingham, 2003), there are six levels of understanding statistics: Idiosyncratic, Informal, Inconsistent, Consistent non-critical, Critical and Critical mathematical. It is beyond the scope of this paper to provide solutions for the introduction of statistics; however, the best approach is through learning by doing, and within the framework of problem- and project-based work, there is enough space for improvement. As a conclusion, it can be recommended that students should begin statistical thinking as early as possible.

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Contact address

Prof. Andrej Šorgo

Faculty of Natural Sciences and Mathematics
Faculty of Electrical Engineering and Computer Science
University of Maribor
Koroška cesta 160
2000 Maribor, Slovenia
e-mail: andrej.sorgo@um.si

PROJECT BASED TEACHER EDUCATION TO DEVELOP MATERIALS, INSTRUCTION AND CULTURE FOR PHENOMENON-BASED STEAM PROJECTS WITH PUPILS IN SCHOOLS

LINDELL Anssi, KÄHKÖNEN Anna-Leena and LOKKA Antti

Abstract

In Finland, the most radical ongoing school reform is fading out the borders around school subjects to better prepare young people for future challenges. The new National curricular guidelines include phenomenon-based learning (PhBL) at all school levels. In teacher education, we have adopted a project-based approach for accustoming teachers to this change. Communities of learners with diverse areas of expertize are called together to accomplish projects, along with student teachers. The driving questions are directing the development of materials and guidance to realize cross-subject educational projects with pupils in schools. We are applying Ajzen's Theory of Planned Behaviour to examine student teachers' salient beliefs for three primary constructs: attitude, subjective norm, and perceived behavioural control defining their intention to accomplish PhBL. The initial data were collected by a questionnaire from 14 special education student teachers, after participating in a Checkpoint Leonardo: Stealth –project to develop teaching for cross-subject science, technology, engineering, arts and mathematics (STEAM) learning sequence. Three of the students were interviewed after the project. The main findings for improving teacher education are the perceived opposition of pupils' parents towards PhBL and the variance of concerns that student teachers have towards realizing PhBL. These findings are used as the basis of an intervention in the following years' project-based teacher education.

Key words

Student teachers‘ beliefs, Phenomenon-based learning (PhBL), STEAM education, Project based teacher education

INTRODUCTION

Finnish 15-year-old students performed extremely well in all categories of the last Programme for International Students Assessment (PISA) 2015. Their rankings were 4th, 13th and 5th in reading, mathematics and science, respectively (OECD, 2016). In the collaborative problem solving test, Finnish youngsters were seventh, ranking second in Europe, right after Estonia

(OECD, 2017). However, we face big challenges: boys' average performance lags behind the girls' average more than anywhere in the world; the trend of the rankings is sharply descending, and school satisfaction is low (Currie et al. 2009). The Finnish National board of Education responds to these challenges with the new phenomenon-based National Core Curricula for basic education, grades 1-9 (2014) emphasizing collaborative methods and PhBL. A search in the contents of this 508-page document gives in total 470 hits for the Finnish keywords meaning inter-disciplinary (PhBL) education. Similar searches with words of "community" (of learners) and "learning environment" give 510 and 284 hits respectively. As the interdisciplinary approach to authentic problems and the use of diverse communities of learners in comprehensive learning environments are the cornerstones of project-based education (PBE) as well (Krajcik & Czerniak, 2014), we may presume that the new Finnish curricula ask for project-based methods.

Also the European commission calls for inter-disciplinary approach in education (Hazelkorn et al. 2015). They indicate that too often science education limits only to knowledge of and methods for understanding physical systems, living systems, earth and space systems and technology, referred to by an acronym STEM (science, technology, engineering and mathematics). In addition to that, we should support arts-based initiatives, e.g. film, media, visual arts, etc. to develop resources promoting science learning, positive views of science and a scientific culture. This approach is called the STEAM focus, where A is for arts.

As STEAM is still a new and exotic approach in education, there are not many materials for teaching. In addition, instruction supporting learners' autonomy, collaborative teaching, and learning in PBE, are unfamiliar to many in-service teachers. To overcome these barriers, we have been developing a project based teacher education model for phenomenon-based STEAM education since 2012. The core idea of this model is that (student) teachers collaborate with the community to develop materials, instruction and the culture for STEAM projects with pupils in schools. The next developmental phase of this model is to study student teachers beliefs about STEAM education, to learn if they are going to utilize the model in practice in the future. From this knowledge, we can develop our PBE model to support student teachers to exploit their resistance to benefit their learning (Bronkhorst et al. 2014). Our research question is "*What kind of beliefs student teachers have about PhBL influencing their intentions to implement STEAM PBE in schools?*"

There exists a huge amount of research reports about teachers' and student teachers' beliefs about various issues. However, we could not find any reports on student teachers' beliefs about PhBL or inter-disciplinary education. Haney et al. (1996) studied teacher beliefs and intentions regarding the implementation of Ohio Competency Based Science Model. They found that attitudes toward implementing the model appear to be critical components to the educational change process. Diakidoy & Kanari (1999) studied student teachers' beliefs about creativity. Their results indicated that student teachers tend to perceive creativity as a general ability primarily manifested in the context of artistic endeavours. They also separate the creative outcomes from the correct answers: creative outcomes were considered novel but not necessarily appropriate or correct. Torff (2015) compared beliefs about learning and teaching in a survey with 214 parents and 196 teachers. He found that parents believe more in curricula and teachers believe more in student-centred way of teaching. The difference should be taken into account in communication between stakeholders. Reeve et al. (2014) investigated the role of three beliefs in predicting K-12 teachers' motivating style toward students. They studied how effective, how normative, and how easy-to-implement autonomy-supportive and controlling teaching motivation styles were believed to be. The average beliefs of this international sample of 815 teachers from 8 countries were that autonomy support was relatively more effective than teacher control, controlling is relatively more normative and easier to implement than was autonomy support.

THEORETICAL BACKGROUND

We are applying Ajzen's theory of planned behaviour (Ajzen, 1985) to find beliefs that influence student teachers' *intention* to engage STEAM PBE. According to this theory, an intention to a behaviour depends on one's attitude, normative beliefs, and control beliefs about that behaviour. These include beliefs about perceived consequences (c_i), others' expectations (f_j) and resources or barriers (p_h) for that behaviour (see fig. 1). How much each of these beliefs affect the intention towards the behaviour, depends on their power in any individual's case. An estimate of whether a perceived consequence is good or bad (g_i) amplifies the attitude component. Similarly, motivation to comply (m_j) with a certain group puts gain on the belief about the expectations of that group. Each resource required by, or barrier against, a behaviour needs to be multiplied by an estimation of one's potential to overcome these (l_h). Multiplying the strength of each salient belief by its estimated individual power we can then determine the direct variables for the attitude (*AB*), subjective norm (*SN*) and perceived behavioural control (*BC*) as averages. The behaviour depends on the intention to the behaviour, which in turn, is dependent on these direct variables. Further, the weight of each of these is still dependent on external variables of demography, general attitudes and personal traits, for example.

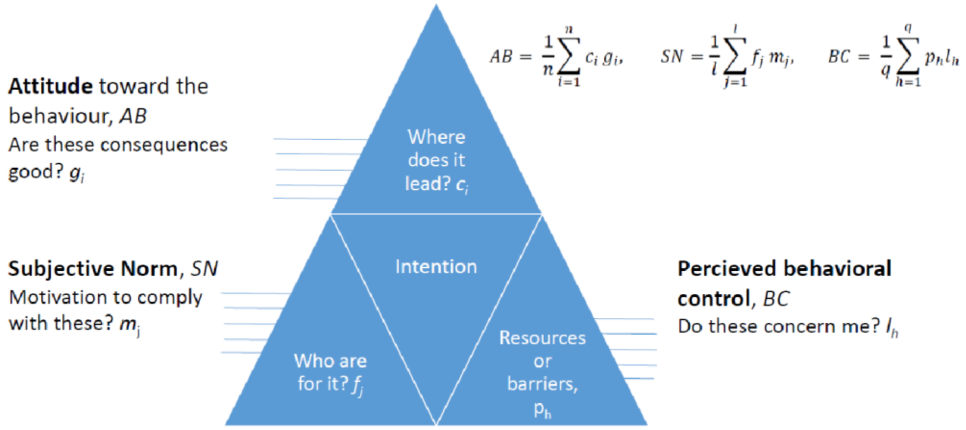

Fig. 1. In the Theory of Planned Behaviour (Ajzen, 1985), beliefs are used to predict an individual's intention to engage in a behaviour using the outlined mathematical model.

We started our study by developing a survey instrument to assess beliefs about PhBL. First, five researchers (including the authors) elicited their ideas about students' attitudes, norms and behavioural control in PhBL. To find the beliefs most salient for students, a group of ten student teachers assessed these ideas by a seven-step agree-disagree scale prior to the project. In addition, they were asked to bring up new ideas by open questions about their beliefs. By the results of this study, we chose n=4, l=7 and q=6 emerging beliefs in attitudes, norms and controls, to construct question pairs to find out the 17 products c_ig_i, f_jm_j and p_hl_h to calculate the direct variables *AB*, *SN* and *BC* respectively (fig. 1). After the project, 15 student teachers responded to the 34 questions (17 pairs of questions) with step scales from -3 to +3. Thus, each product is a number between -9 and +9. One student from each of the three project groups was called for a semi-structured interview to revisit their pre-questionnaire answers. Roughly described, one student was in favor of, one against, and one with a neutral attitude towards PhBL.

CONTEXT, TASKS AND LEARNING ENVIRONMENTS DURING THE COURSE

The CPL Stealth extended group included four colleagues at the University of Jyväskylä, a supervisory board with eight members from various fields and the head curator from Jyväskylä City art museum. This study was realized within an applied, PhBL course combining pedagogy of arts (2 ECTS) and science (3 ECTS). The course was taken by 15 student teachers (elementary school / special education, 2nd year students).

The course programme started with a VTS (Visual Thinking Strategies) demonstration that was held at the Art museum, focusing on three young Finnish artists` exhibition (https://www.jyvaskyla.fi/taidemuseo/nayttelyt/hautamaki_havia_somervuori). VTS is the product of a research-based education nonprofit that believes thoughtful, facilitated discussion of art activates transformational learning accessible to all (Housen 2002). The second meeting had preliminary, classical inquiries about vision. Science included inquiries about light sources vs. reflected light, colours, contrast, resolution and lenses vs. apertures. From the artistic point of view, we promoted for instance ideas about looking and likeness: Two colours look alike, A colour has many looks, Additive and subtractive mixing and mixing shades (Albers, 2013). Next the project groups (A - Invisibility cloak, B - Chameleon and C - Camouflage) started designing and testing teaching materials for 3 x 45 min. lessons for 3-6 graders. Topic was to inquire the phenomenon of (in)visibility. The groups presented their teaching materials to the CPL extended groups and improved upon feedback.

Eventually, groups A and C used their teaching materials at local Puistokoulu -school with 4th and 5th grade pupils and group B hosted a workshop at the Natural history museum of Central Finland. After the teaching experiences were finished, we hosted an evaluation session for the groups at the university.

RESULTS

The student teachers' most salient beliefs addressed in our PhBL questions, and the averages of the assessed effects of these beliefs, are presented in Table 1. The calculated averaged sums in the sample for *AB (Attitude), SN (Subjective norm)* and *BC (Perceived behavioral control)* are 4.1, 3.6 and 3.75 respectively. The beliefs that assign most advantage to PhBL are the perceived positive example set by pedagogy experts and possibility of co-teaching with colleagues. The only belief regressing the intentions to utilize PhBL was the belief that parents of pupils oppose PhBL. The three interviewed students were given pseudonyms describing their attitudes to PhBL. They represent three profiles of innovation adapters; each with important strengths and utilizable value in the teacher community.

Table 1 Averages of the effects of salient beliefs on intention to utilize phenomenon-based learning.

	Average of the strength of salient beliefs multiplied by its estimated power				
Attitude, $c_i g_i$	Self-gui-dance, 2,9	Motivation, 4,3	Theory and practise, 4,6	Creativity, 4,6	
Subjective norm, $f_j m_j$	Parents, -1,0	Teachers, 1,9	Pupils, 5,2	Curricula, 5,2	Pedagogy experts, 6,8
Perceived beha-vioral control, $p_h l_h$	School cul-ture, 0,6	Resources, 1,6	Education, 6,0	Co-teac-hing, 6,8	

The first, Ada Adapter, believed in benefits of PhBL: *"Pupils gain such skills and thinking strategies that they can benefit from in their real life and environment, more than* *studying something minor within a school subject".* She also counted on pedagogy experts and curricula: *"Because phenomenon-based learning and integrating different subjects is supported [by these instances], there must be some evidence for its benefits".* Ada considered collaboration between teachers important, wishing for *"a good professional community and atmosphere and time for co-operation and good colleagues who are engaged in (phenomenon-based) practise. Co-teaching or just a collaboration and discussing together".* Her strength is in openness and being an early adoptee, ready to try out different things.

Priscilla Pragmatic longed for concrete resources for teaching: "*There will be no time or resources for that"* and *"Concrete examples and materials are needed, so that one won't need to start to build everything from scratch".* She approached the issue from the school community point of view, saying: *"In practise, everyone but the teachers are rallying for [phenomenon-based learning], but those who need to do the job are not quite in on it yet"* and *"Of course one must listen to the experts and follow the curriculum, but mainly the teacher colleagues who are around…in one's own professional community."* Her strength is in building a strong teacher community and ensuring support: not setting out on a new path alone, unless there are fellow colleagues sharing the journey.

Christine Critical doubted that all learning should be phenomena based. *"In our (pedagogical) studies we have done so much phenomena based projects, that we are already tired with them… There should be a limit for how many can be done at a time."* It was almost as if a confession to make: *"Sometimes it is nice to study, you know, so that you read a topic from a book and do the exercises."* She also considered critically the possibility of PhBL in a class of a new teacher *"If I consider, when I start as a teacher, well– I'll be a new teacher and it will be my first year and it would probably take all my resources more to that I will learn more effectively and manage the group of pupils and it may be so that in the beginning I need to go by a more traditional model, but after gaining some routine for my own action it might clear up and it might be easier for me to see those whole topics."* Her strength is in looking at the personal resources of each actor in the process and recognizing possible difficulties ahead of time; she will plan her way around difficult spots and be able to lower the bar until she or her students are back in full strength.

CONCLUSIONS

We approached our research question from two directions: what are the actors influencing student teachers' opinions and beliefs - and ultimately their intentions - about PhBL, and is there considerable diversity amongst the intentions within a group of student teachers? The reason for doing this study is in improving our teaching so that it better meets the needs of our student teachers. Here we revisit these results and envision relevant improvements.

From the initial stages of questionnaire making and assessing, we were able to list belief components in categories of attitude (*AB*), subjective norm (*SN*), and perceived behavioral control (*BC*). The use of TPB allowed us to compare the relative strengths of the effects of each category and component. While in the pre- and post-questionnaires we allowed for student teachers to also write open answers, no new components arose from these responses. We consider the listed examples in Table 1. to be a fair representation of actors and salient beliefs influencing student teachers' intentions towards utilizing PhBL.

The whole group had an overall positive attitude towards PhBL. When interviewing student teachers whose answers were off from the averages, we gained a more nuanced picture of their concerns and intentions. We understand now that for some teacher students, the ownership of self-created learning materials does not outweigh the time and effort spent creating them, and they would benefit from knowledge that ready, easily accessible materials are also available for PhBL. For some teacher students, project-based instruction had become a burden; for these students, we wish to convey that project-based learning is one instructional technique amongst many and there certainly is a time and place for it, but it is not for all time.

In the next iterations, we will be able to target some of the overall high-ranking influences to student teachers' intentions towards teaching with PhBL techniques, and give positive examples about them. We will also be pinpointing some of the lower ranking influences, such as the in-service teachers, and especially the parents (who were perceived in the opposition), and designing an intervention where the student teachers have an opportunity to meet with representatives of both groups.

We can also offer targeted support according to student teachers' individual answers in the pre-questionnaire in the future courses, and discuss the different stances towards PhBL within the group, highlighting the strengths and support needed by each profile.

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Contact address

Anssi Lindell, Anna-Leena Kähkönen, Antti Lokka

Department of Teacher Education
University of Jyväskylä
Finland
e-mail: anssi.lindell@jyu.fi, anna-leena.m.kahkonen@jyu.fi, antti.lokka@jyu.fi

MINTEGRATION: STEM ACTIVITIES FOR REFUGEE KIDS

LINDNER Martin, LIPPMANN Jette, KORZENG Anna-Lena, SCHEWNIN Anita, NENTWIG Stephanie

Abstract

The immigration of refugees into Europe is a challenge to the educational institutions. In Germany, the children are gathered in so called Welcome Classes. In these classes they are learning languages, basic facts about Germany and about the school system. Usually they stay in these courses for one year, until they reach a level of German to join regular classes.

Since December 2016 we are visiting schools in the vicinity of the University of Halle to offer STEM education courses especially created for welcome classes. The five days program contains an approach towards STEM related aspects of the human body like hygiene, healthy nutrition, drug consumption, and sexual education. The learning is organized along many practical activities and experiments. The classroom work is prepared and taught by teams of teacher students. One of these weeks was evaluated by a group of three students who were part of our project practicum this summer term. The data were collected by evaluating mind maps of the students.

Key words

IBSE, refugees in Europe, evaluation with mind-maps

INTRODUCTION

Since 2010, with a peak in autumn 2015, many refugees from conflict areas in the near east reached Germany, in 2015 alone these were 800.000 persons. This immigration challenged the German society in many ways, and for the young immigrants, especially those who came unaccompanied by parents, special school programs were implemented, the so called “welcome classes”.

Most of the refugees wanted to live in the vivid international societies of the cities in the west of Germany, and also in Berlin. They had relatives and national contacts there. Due to this movement only few refugees settle in the east of Germany, the former GDR under the dictatorship of the Soviet Union. Concerning this fact it is surprising, that in East Germany more people are voting for xenophobic, nationalistic, anti-islamic parties than in the West: there are only a few refugees and they don´t know them.

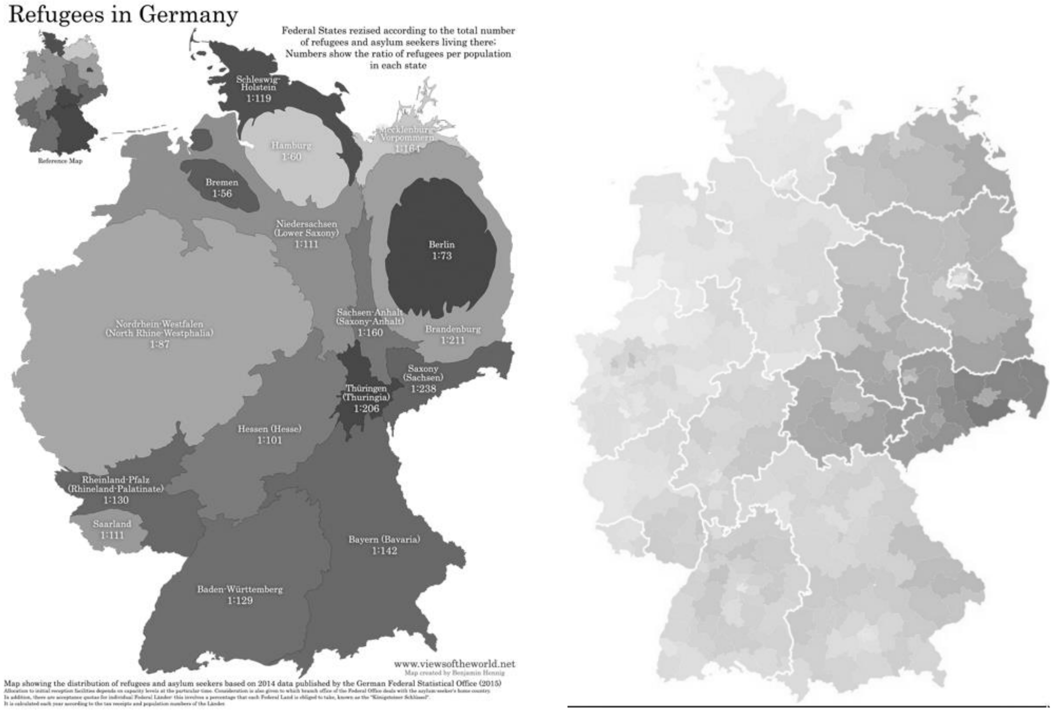


Fig.1 Refugees in Germany (left) and voters for xenophobic parties (right). The figure on the left shows the German States in the proportion of refugees seeking for asylum per population of that state. Source: www.viewsofththeworld.net . The figure on the right shows the proportion of the votes for the xenophobic party in the national election in September 2017. The darker the grey, the higher the proportion (source: https://interaktiv.morgenpost.de/analyse-bundestagswahl-2017/)

Concerning this background, it is more necessary to start initiatives in East Germany to help refugees to integrate into the educational system, to give them a really welcome classroom and to provide them with job opportunities, e.g. in the STEM sector.

The department of Biology Education of the Martin-Luther-University in Halle, located in the German State Saxonia-Anhalt (former GDR) has a long-term experience of organizing international science camps (Ivánková & Rusek, 2016; Rusek & Lindner, 2017) where refugees took part too. Therefore the staff of the department started the initative “MINTegration” with the support of the Bayer Education Foundation in 2016 (the title is a mixture of the German word for STEM, which is MINT, and Integration). The concept is a teaching design for a five days program on the human body, including hygiene, healthy nutrition, abuse of drugs and sexual education. These five days are held in groups of 2 or 3 teacher students in different schools in and around the city of Halle.

METHODOLOGY

Up to now these activities were designed and carried out with great effort and enthusiasm of the teacher students, however, an evaluation has not been done yet. With this paper we demonstrate the first attempt to evaluate our program with scientific methods. These methods have to deal with the fact that most refugees are not safe in the German language, nor in English (and also do not have a common native language, as they come from many countries from Afghanistan, Syria or West Africa).

Due to the language variety we chose the method of concept maps with pictures (Fig. 2). These pictures should be commented in that way, that the pictures should be named and connections between them should be marked and commented.

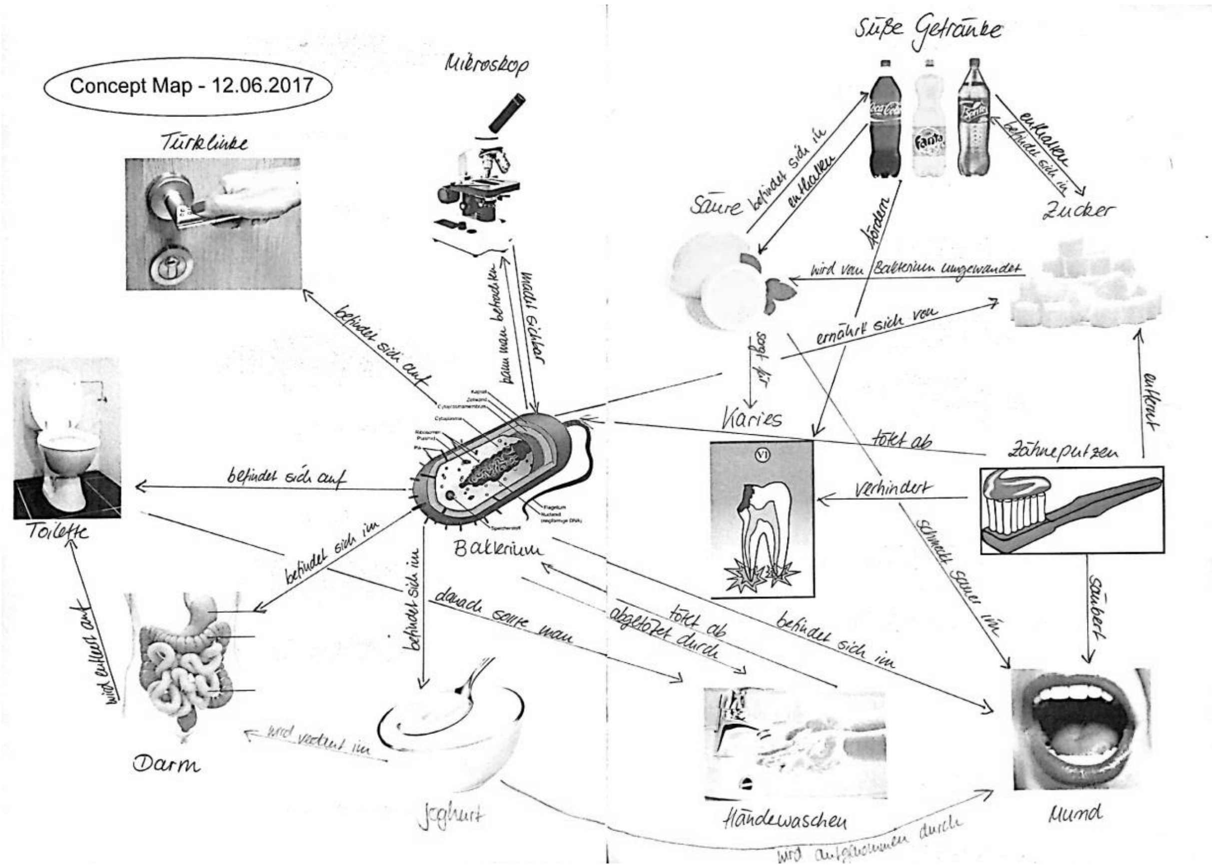


Fig 2: Concept map of pictures, with the all correct connections and comments (in German)

The concept maps were distributed to the students before starting the project (= pre-test) and after two days (= post-test). In these two days the teaching included two topics “bacteria” and “healthy nutrition”. The test allows a comparison of previous knowledge and the new learned concepts and their connection. Problems occurred were the following: (1) Students did not know the method „Concept Map” and (2) Limitation by language skills.

We distributed points to compare the first with the second Concept Map

◦1 point for the right vocabulary in German

◦1 point for each arrow

◦1 point for the comment on the arrow

◦ 0,5 points for a word that was almost right, but spelled wrong

RESULTS

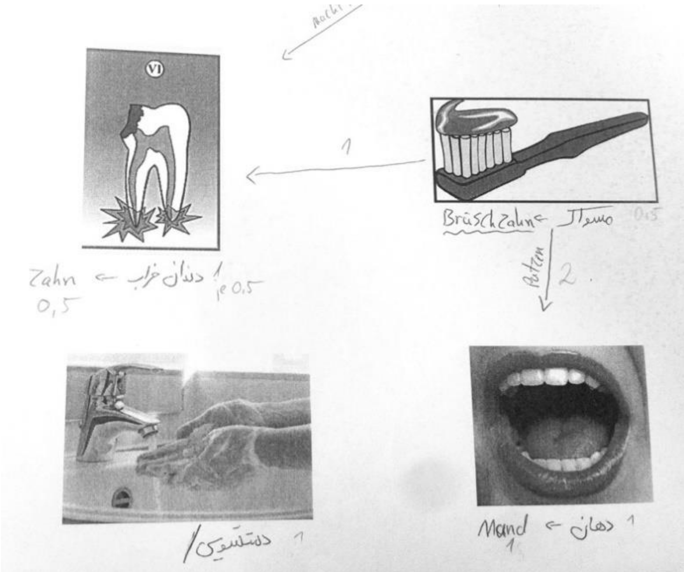
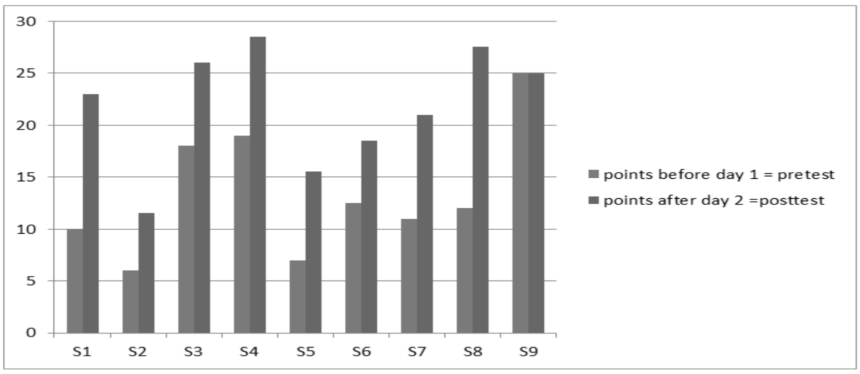


Fig. 3: Example of a part of a student´s mind map with Arabic and German vocabulary. The numbers are the evaluator´s marks on the concept map. Comment: the words in German are quite wrong, however you can guess the meaning.

After two days of the STEM activity the students' answers were rated in the following amounts:



Comparison from the pre- to the posttest

Fig. 4: Comparison of the points of pre- and post-test of 9 students (S1-S9)

After the teaching the students gained more points with one exception. Student no.9 did not understand the task and only repeated the first mind-map, in which he was already good. If we go more into detail, we find different patterns to deal either with the vocabulary or the connections (Fig. 5).

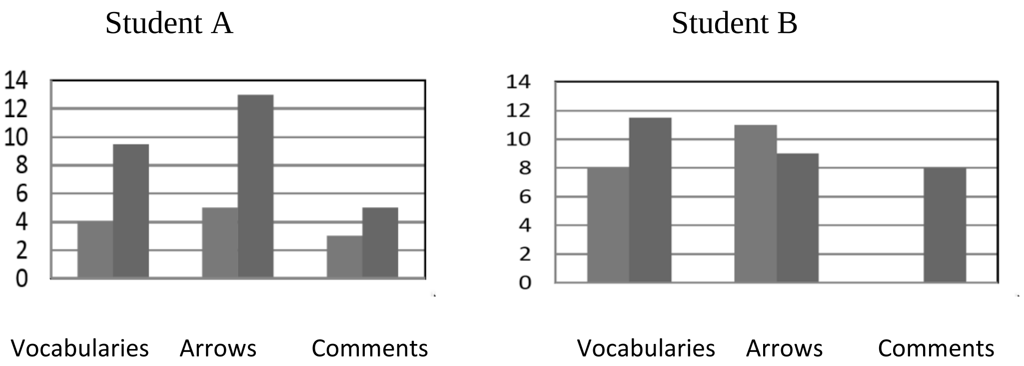


Fig. 5: Comparison of the points of pre- and post-test of two students concerning different aspects given in their mind-map. Light grey: pre-test, darker grey: post-test.

DISCUSSION AND CONCLUSION

The results give a clear picture: every student learns about the vocabulary and also learn about the concept behind the activities, as they could not only draw the arrows but also the comments on them were improving very much (Fig. 4). Of course we have to take into concern the data were gained from a small group of persons, however they indicate a success in our teaching activities. Student No. 9 did not learn new things, this might be due to an error in understanding the task. It was clear that this student had already in the pre-test a wider understanding than the others.

If it comes to a more detailed comparison between single students, the data show a differentiated picture on the performance of single students (Fig. 5). As student A shows a smaller learning amount compared to student B, he really improves in all categories. Student B shows a clear improvement in commenting the arrows, however shows a small decrease in drawing correct arrows. This might also be a side-effect of his intense work on the other categories.

Our data could not prove the other implications we have with our project. The job perspective was not researched, and also the aspects of integration. Further research is needed to improve knowledge on the amount of integration we could reach by programs like this. As we are now starting to conduct our activities in mixed classrooms with German and refugee students, we will be able to research the feelings and the cooperation of both groups. The career aspect will be included in interviews which we are planning for the next training courses.

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Contact address

Prof. Dr. Martin Lindner, Jette Lippmann, Anna-Lena Korzeng, Anita Schewnin, Stephanie Nentwig
Martin-Luther-Universität Halle-Wittenberg
Biologicum, Weinbergweg 10
06099 Halle
e-mail: martin.lindner@biodidaktik.uni-halle.de

KONFERENCE O PROJEKTOVÉM VYUČOVÁNÍ: OHLÉDNUTÍ ZA 15 ROČNÍKY

Project-based Conference: A Lookback after 15 years

RUSEK Martin, VOJÍŘ Karel

Abstract

The paper contains results of a content analysis performed on the papers published in the proceedings from the previous fourteen years of the conference Project-based Education in Chemistry (1st–7th), Project-based Education in Chemistry and Related Fields (8th and 9th) and Project-based Education in Science Education (10th–14th). More than 200 papers were analysed. As far as the topics are concerned, the traditional focus on practical examples of projects have been complemented with topics about inquiry-based education and also theoretical papers in the last several years. The trends suggest not only growing numbers of participants, but also orientation to broader spectrum of topics which are represented by student activating strategies. The most frequent topic concerns salt followed by topics concerning food, water and environment.

Key words

Content analysis, school projects, research trends

ÚVOD

U příležitosti patnáctého výročí konference o projektovém vyučování se nabízí ohlédnutí za předchozími lety. Tento příspěvek je obsahovou analýzou textů publikovaných ve čtrnácti konferenčních sbornících od roku 2011 – roku započetí tradice „projektových konferencí“.

Při analýze jednotlivých textů bylo zapotřebí zohlednit koncepci jednotlivých ročníků konference a jejich vývoj. Do roku 2009 byla konference orientována pouze na studenty učitelství a jejich návrhy projektů. Další požadavky (ověření v praxi, podložení efektivity výzkumem apod.) nebyly na texty kladeny. Po roce 2010 se do řad účastníků začali řadit studenti z dalších pracovišť, přibyli studenti doktorského studia a také zahraniční účastníci. Konference se také otevřela dalším přírodním vědám.

Cílem tohoto článku je poskytnout čtenáři informace o vývoji konference a jejím potenciálním dopadu na školní praxi. Záměrem autorů je také sumarizovat stav poznání, které autoři jednotlivých textů prezentují ve sborníkových příspěvcích a vytvořit tím jakýsi maják pro další autory působící v této oblasti.

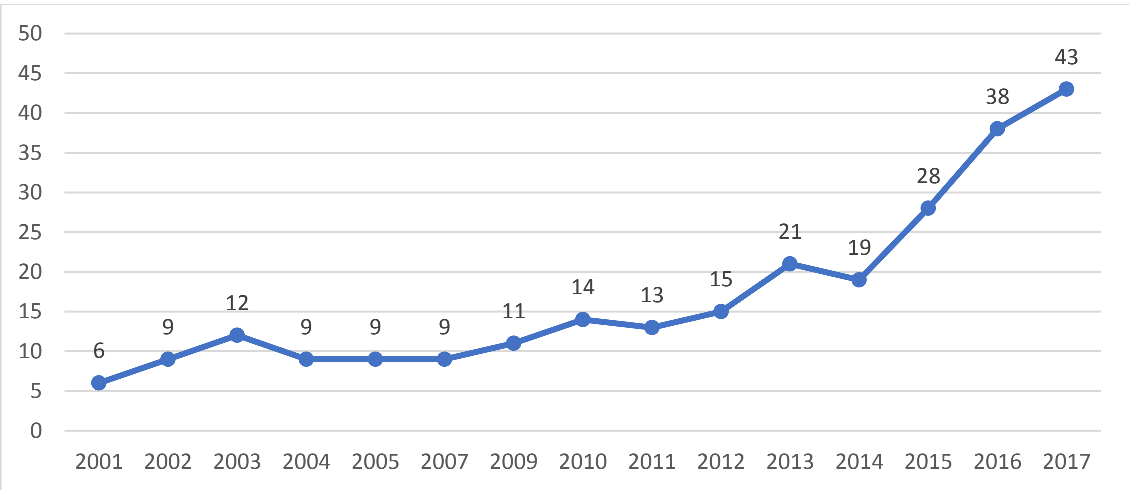
METODOLOGIE

Analýze byly podrobeny všechny texty publikované ve sbornících z konference Projektové vyučování… mezi lety 2001-2016 a texty z roku 2017 zaslané autory do konferenčního sborníku. Při analýze byla využita standardní procedura, tj. byli sledováni autoři, pracoviště autorů, obor, témata, klíčová slova, počty publikací atd.

Analýza probíhala kvalitativně, její výsledky pak byly pro účely dalšího zpracování kvantifikovány. Synonymní klíčová slova v různých jazycích (či skloňování a jejich zkratky) byla sjednocena a vyhodnocována v součtu. Pro potřeby identifikací témat byly nejprve zvoleny kategorie používané v textech zaměřených na výzkum v didaktice přírodních věd (Lin et al., 2014; Teo et al., 2014). V případě výskytu dalšího tématu byly kategorie přidávány. Méně početně zastoupené kategorie byly v případě příbuznosti sloučeny.

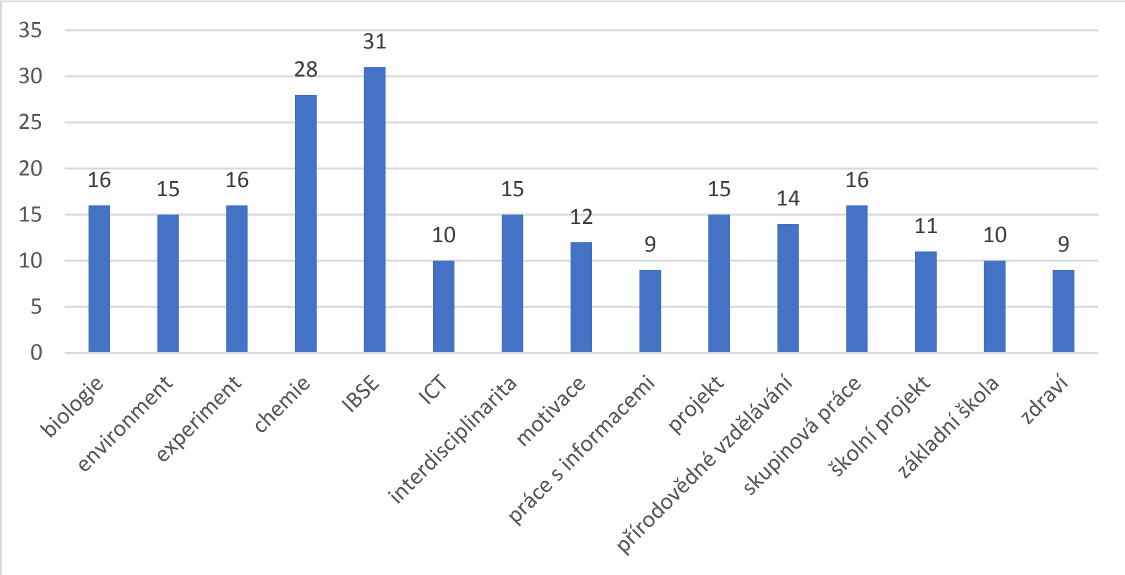
VÝSLEDKY

V konferenčních sbornících od roku 2001 vyšlo celkem 254 článků. Grafickým zobrazením vývoje jejich počtu je graf 1. Z výsledků vyplývá nárůst příspěvků. Ten je dán především zvyšujícím se zájmem akademiků.



Graf 1 Počty příspěvků publikovaných v konferenčních sbornících v jednotlivých letech

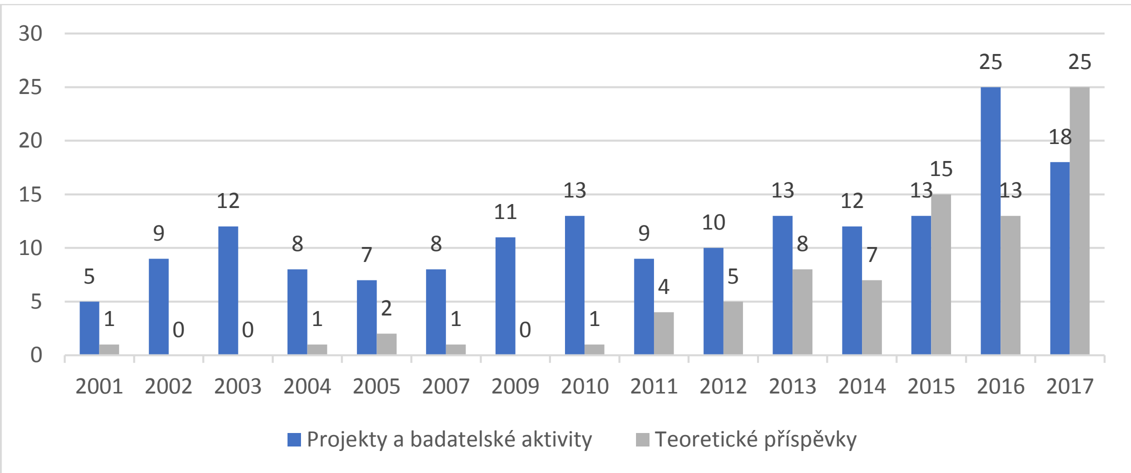
O zaměření jednotlivých textů vypovídají klíčová slova volená autory příspěvků. Přehled nejčastěji používaných je uveden v grafu 2. Pro vyšší přehlednost bylo ze souboru odstraněno klíčové slovo PBE/project-based education apod., které bylo zastoupeno 128krát. S ohledem na název konference je jeho použití autory zřejmé a nemá tak přílišnou výpovědní hodnotu.



Graf 2 Počty klíčových slov zvolených autory jednotlivých textů v konferenčních sbornících

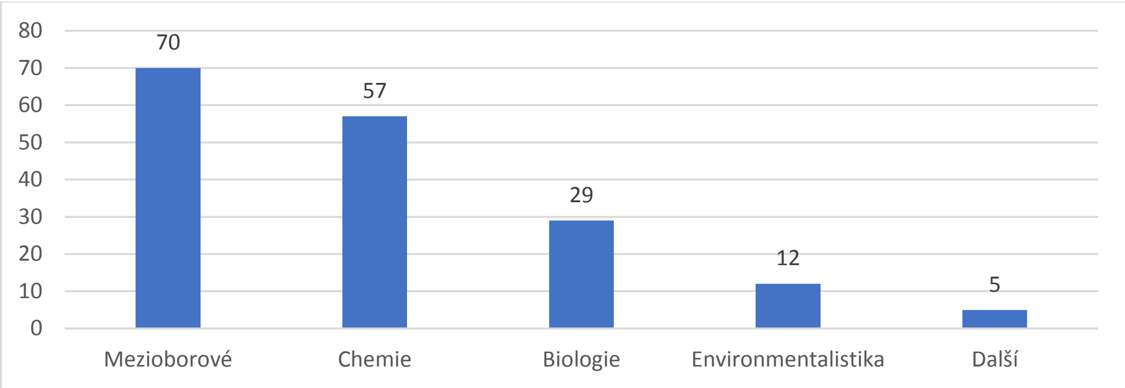
Z výsledků vyplývá, že mimo projektového vyučování autoři příspěvků cílí nejčastěji na badatelsky orientované vyučování, uvádějí obor zaměření příspěvku a jednotlivé charakteristiky projektového nebo badatelsky orientovaného vyučování.

Analyzované texty byly pro účely dalšího popisu děleny do dvou skupin: teoretické texty a texty praktické povahy. Počty těchto textů publikovaných v jednotlivých sbornících jsou uvedeny v grafu 3. Z výsledků je zřejmé, že v průběhu let se zvyšuje poměr teoretických příspěvků. Tento trend je z části způsoben vyšším podílem akademiků mezi účastníky konference, z části se jedná o přirozenou potřebu autorů ukotvit vybraná témata, která se v poslední době stávají hojně diskutovanými. Tyto snahy vedou k tříbení oborů a dalšímu pokroku v dané oblasti. Z tohoto pohledu je velmi žádoucí tento trend udržovat.



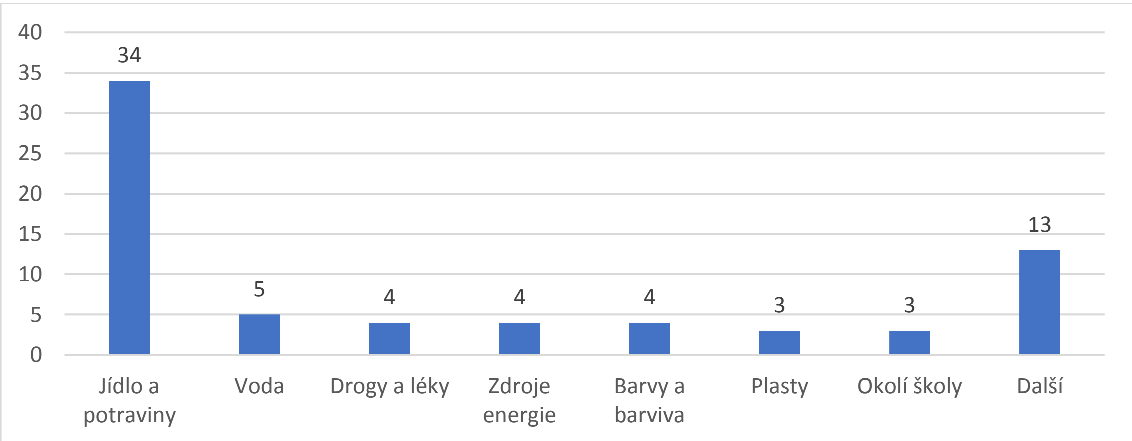
Graf 3 Počty praktických a teoretických příspěvků publikovaných v jednotlivých letech

Dalším kritériem analýzy textů bylo samotné zaměření na daný obor. Jak je zřejmé z grafu 4, autoři nejčastěji volí mezipředmětová témata. Vyšší podíl chemicky laděných textů je možné interpretovat historickým vývojem konference (název se z původního Projektové vyučování v chemii změnil až v roce 2011), zároveň je zde patrný vliv pořádajícího pracoviště a spolupráce s katedrou učitelství a didaktiky chemie Přírodovědecké fakulty UK.



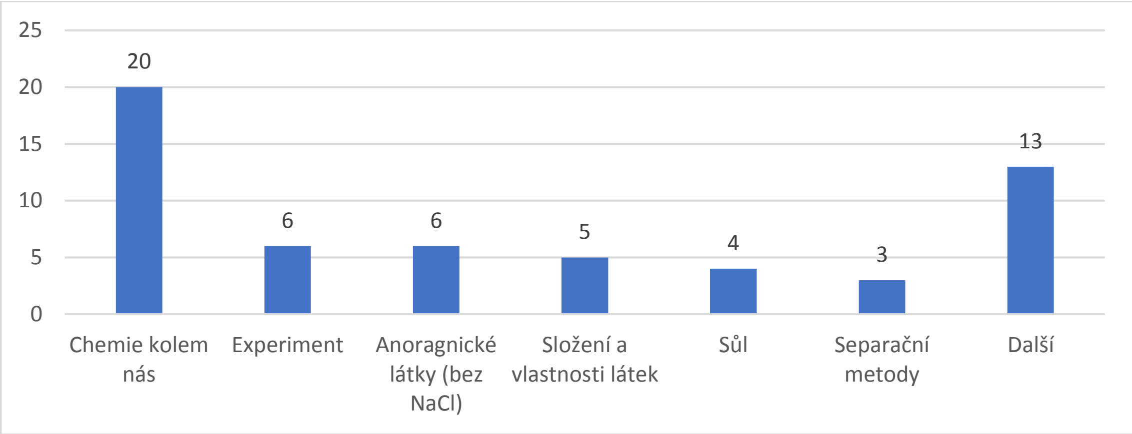
Graf 4 Zaměření jednotlivých příspěvků

Zaměření mezioborově laděných textů je zobrazeno v grafu 5. Jednoznačně nejčastěji rozpracovaným tématem je jídlo. Autoři většiny praktických projektů se snaží aktualizovat vzdělávací obsah žákům blízkými informacemi z jejich každodenního života (srov. Stuckey et al., 2013). V této kategorii se vyskytují projekty s názvy: Není nám jedno, co jíme! (Moldaschlova et al., 2015), Víš, co jíš? (Krejcikova & Vojtajova, 2015) apod. V rámci této kategorie se autoři nejčastěji věnují životosprávě (13), dále sacharidům (6), vitamínům (4), nebo „éčkám“ (3). Integrujícím tématem bývá mj. i voda, která nabízí různé úhly pohledu na problematiku.



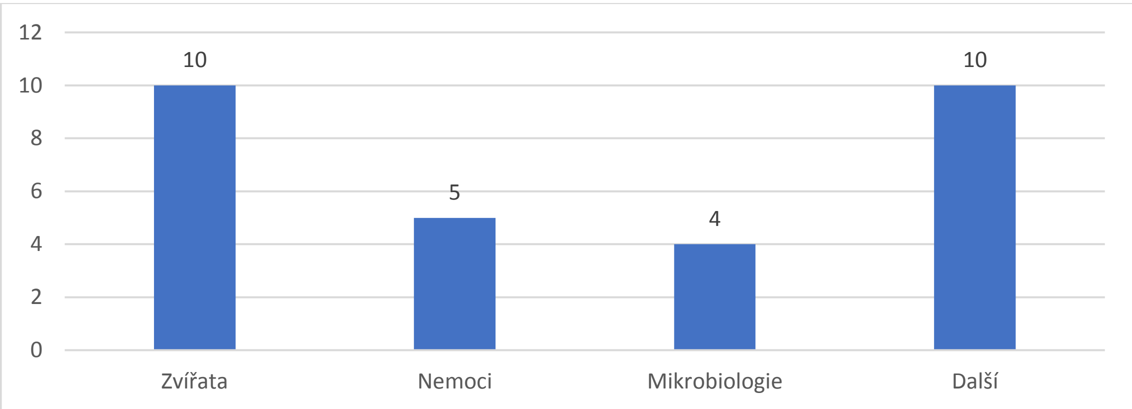
Graf 5 Zaměření mezioborově laděných projektů nebo badatelských úloh

Zaměření chemických, prakticky laděných projektů či badatelských úloh dominuje tématika *chemie kolem nás*. Autoři se dále věnují i experimentům nebo složení a vlastnostem látek. Zvláštní skupinu tvoři anorganické látky, z nichž byl pro zajímavost vyčleněna tématika soli, kterou se autoři projektů s názvy *Sůl nad zlato* (Balonova & Urbancova, 2013) apod. věnovali v porovnání s ostatními tématy více (viz graf 6).



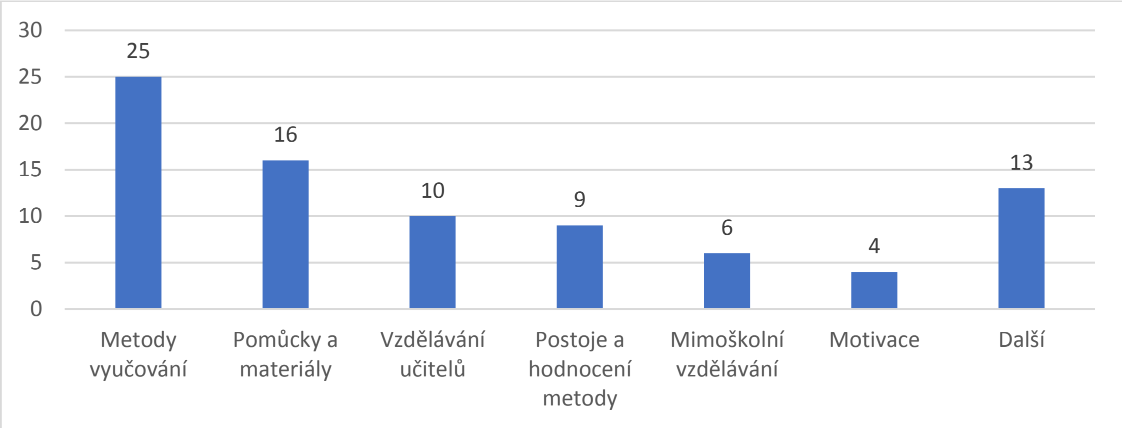
Graf 6 Zaměření chemicky laděných projektů nebo badatelských úloh

Zaměření biologických, prakticky laděných projektů nebo úloh je v porovnání s chemickými tématy poněkud vyrovnanější (viz graf 7). Nejčastěji se autoři v této skupině zabývají jednotlivými druhy zvířat, případně nemocemi a mikrobiologií. V kategorii další jsou umístěny texty, které pro jejich pestrost nebylo možné zařadit.



Graf 7 Zaměření chemicky laděných projektů nebo badatelských úloh

Identifikace témat teoretických příspěvků byla obtížnější z důvodu jejich překryvu. S jistou dávkou zjednodušení však byly použity kategorie uvedené v grafu 8.



Graf 8 Zaměření teoreticky laděných textů

Nejpočetnější skupinu nazvanou *Metody vyučování* představují texty věnované především kritériím projektové výuky nebo badatelsky orientovaného vyučování, rozbor dalších aktivizačních strategií apod. (např. M. Rusek & Becker, 2011; Šindelková et al., 2016) Další skupina shodně zaměřených textů publikovaných především v posledních letech se zabývá pomůckami nebo výukovými materiály typu učebních úloh (Vojíř et al., 2017). Nezanedbatelná část textů byla věnována i vzdělávání učitelů a to jak v pregraduálním, tak i postgraduálním studiu.

S ohledem na obsah analyzovaných příspěvků je mimo uvedené členění zapotřebí zmínit otázku empirie. Výše bylo uvedeno, že podíl v praxi ověřených (nebo alespoň částečně ověřených) námětů stupá. Pozitivním trendem je i snaha autorů o empirický doklad efektivity dané aktivity. Zpravidla se jedná o klasický pre-test – post-test design, pedagogický kvazi-experiment nebo test (e.g. Lindner & Neubert, 2015; Rudolph et al., 2015). Objevují se ovšem i kvalitativní přístupy – jedním z mnoha je využití metodiky 3A k analýze science kempu (Ivánková & Rusek., 2016; Martin Rusek, 2016). Tato skutečnost přidává problematice na vážnosti a napomáhá rozvíjet a dále posouvat výzkum v didaktice přírodních věd.

ZÁVĚR

Přesné dělení sborníkových příspěvků na praktické a teoretické, natož do jednotlivých kategorií, se vyznačuje určitou mírou zkreslení. Přesto však na základě klíčových slov a následně i obsahu každého textu bylo možné text zařadit do některé z výše diskutovaných kategorií. Limitem této studie tak je možná nepřesnost vzniklá širokým záběrem určitého textu, který byl vždy zařazen do jedné kategorie. Hlavním přínosem tohoto textu je zevrubný přehled o šířce problematiky, kterou konference Projektové vyučování za dobu svého konání pokryla.

Zvláště lichotivým rysem je, že se z původně ryze studentské akce stala konference, na které vystupují i zahraniční odborníci. Neopominutelným je i fakt, že mnoho studentů zde publikuje svůj první příspěvek, který pak může stát na začátku jejich publikační kariéry. Z hlediska obsahu je pozitivním trendem nárůst teoreticky zaměřených příspěvků, ve kterých autoři pokrývají širokou škálu problematiky projektového a badatelsky orientovaného vyučování. Tento přínos konference a konferenčních sborníků spočívá především v potřebě přesně definovat termíny tak, aby i pedagogický výzkum v této oblasti mohl stavět na pevných základech. Velmi často zmiňovaný problém příliš volného používání slova projekt v praxi patří mezi zářné příklady. Z jednoho úhlu pohledu sice učitelé v praxi zkouší modernizovat svou výuku a zařazují tzv. projektové dny. Opřené o teorii projektového vyučování by tyto školní aktivity mohly být efektivnější. Rozlišování projektu, tematicky pojatého integrovaného vyučování, vzdělávacího programu nebo školní aktivity je tak zcela zásadní.

Dalším trendem je výskyt textů orientovaných na jinou problematiku, než je projektové vyučování. Badatelsky orientované vyučování jako přirozená součást projektů není překvapením. Autoři však stále častěji vybírají další prvky, které je sice možné uplatnit v projektové výuce jako nejširší organizační formě, nicméně jsou i samostatně využitelné. Orientace konference se tak podstatně mění a téma otvírá na obecnou úroveň aktivizačních strategií řízení učební činnosti žáků.

Pozitivním zjištěním je i nárůst empiricky podložených textů, které tak umožňují další rozvoj výzkumu v oborových didaktikách. Jako žádoucí je rovněž možno hodnotit stoupající důraz na přípravu učitelů, a to jak na pregraduální, tak i na postgraduální úrovni. Předpoklad, že učitel v praxi začne zapojovat projektovou výuku, aniž ji sám vyzkoušel, je málo pravděpodobný. Proto je zapotřebí nejen utvářet kurzy, v rámci kterých si (budoucí) učitelé projekty vyzkouší. Vhodné je i podpořit případné uživatele dokladem o efektivitě této formy výuky.

V úvodu zmíněná role majáku ve zkoumané oblasti je pro organizátory konference zásadní iniciativou. Analýzou provedenou pro účely tohoto textu bylo zjištěno, že mnoho témat nebo dokonce celých projektů se opakuje, aniž by autoři projevili znalost předchozích prací. V zájmu progresivních snah je tak jedním z dalších apelů autorů tohoto textu, aby autoři spíše přebírali již publikované práce, ty upravovali a dále ověřovali. Jedině tak lze tříbit kulturu didaktiky přírodních věd, což je hlavním smyslem konference Projektové vyučování… Situaci by rovněž napomohl větší důraz na empirické ověření výsledků navržených činností. Autoři tohoto textu si uvědomují, že evaluačních nástrojů pro projektové nebo badatelsky orientované vyučování není mnoho, ovšem dílčí výsledky i volené přístupy by mohly být v této oblasti velmi přínosné pro celou komunitu didaktiků přírodních věd.

PODĚKOVÁNÍ

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Contact address

PhDr. Martin Rusek, Ph.D., Mgr. Karel Vojíř

Katedra chemie a didaktiky chemie,
Pedagogická fakulta,
Univerzita Karlova
M. Rettigové 4
116 39 Praha 1
e-mail: martin.rusek@pedf.cuni.cz, karel.vojir@pedf.cuni.cz

IMPLEMENTATION OF ISHIKAWA DIAGRAM INTO PROJECT BASED EDUCATION

CIEŚLA Paweł, NODZYŃSKA Małgorzata, BAPROWSKA Anna, BÍLEK Martin

Abstract

One of the very important aspects of project based education is the process of planning long-term activities during the preparatory phase, however this stage is often not worked out in deep detail. Planning should be done mainly by learners, however this process is difficult for them, especially at lower education levels. The Ishikawa Diagram is a widely used tool for business purposes, especially in product design and quality defect prevention so that to identify potential factors causing an overall effect. This tool can be easily implemented in the project based education. The implementation is discussed within the paper.

Key words

Learning by Design, Project Based Learning, Teacher Preparation, Science Education

INTRODUCTION

The history of project based education (PBE) is hundreds of years old, however John Dewey, Heard Kilpatrick were those who gave this method theoretical background at that times (Nodzyńska, 2015). Project based education has been experiencing a renaissance in recent years. Based on this strategy, many activities are undertaken practically at every stage of formal education as well as in non-formal and informal educational areas.

Many teachers and learners focus mainly on the main phase, i.e. the conducting of the project, while the preparatory phase also plays a very important role and should be treated very seriously. It should cover the following steps:

– Stimulus – starting idea and initiation of the project,

– Selecting the theme of the project and determining what the product will be,

– Detailed planning of work and division of activities and responsibilities,

– Preparation and signing the contract.

During this preparatory phase most attention is paid to initiation of the project, selection of its topic and determination what product will arise. Since PBE strategy aims at preparation for life and promotes learning by solving real problems in real environment (Rusek & Dlabola, 2013), these two first steps of preparatory phase are of crucial importance and they can determine pupils´ motivation. However, special attention should be also paid to the process of planning activities, especially long-term activities in long-term projects. This is usually a stage that is underestimated, minimized, or not deeply treated (Bílek, Machková & Chroustová, 2016).

However, the way of planning influences the final success, or failure of the project. All activities, either close, basic, or distant ones should strive to make product complete and refined. It is why the planning process should include a thorough analysis of various aspects of the project. Therefore, at this stage, learners should:

– Foresee all directions of work,

– Define what needs to be done,

– Define what resources they need,

– Foresee, what can go wrong,

– Plan the time schedule of the project and deadlines for the implementation of individual activities (Time management).

In projects carried out in enterprises or by adults, the Gantt diagram (Gantt, 1910) is most frequently used for time planning; however, due to its structure and complexity, it seems inappropriate especially for younger learners.

Planning the activities within the project and time planning, although it is the basic precondition of success, is rarely researched and described from the didactic view, and there are only a few papers indexed in WOS database concerning that subject, for example (Baprowska & Bilek, 2017)

The PBE theoretical background enforces that planning should be done mainly by learners. However, learners do not have appropriate skills to carry out this process entirely by themselves. In frames of formal school education there is no subject developing such skills. Thus the process of planning the work within the project is difficult for them, especially at lower education levels, because they are not used to applying the holistic and detailed planning in general. In daily routine, pupils prefer coming across close and simple goals step by step, so they need help with planning in projects; they should be equipped with a tool which will help them in this area.

Therefore, it was decided to apply a tool supporting the process of planning subsequent activities in the project. Analysing the needs and available tools, the Ishikawa diagram was chosen, which works well for the cause – effect analysis of relations.

THE ISHIKAWA DIAGRAM

The Ishikawa Diagram (Ishikawa, 1976), also known as a fishbone, is a widely used tool for business purposes, especially in product design and quality defect prevention to identify potential factors causing an overall effect.

The analysis of the problem starts with drawing the 'fish head' – i.e. the description of the occurring effect (usually undesirable), and drawing the 'fish skeleton' – i.e. a graphical representation of all possible negative factors that could cause the (negative) final effect. To explain the reasons, Ishikawa listed five (plus one) main components to be solved – so-called 5M+E (Fig. 1.):

- Manpower (people),
- Methods,
- Machinery,
- Materials,
- Management,
- Environment.

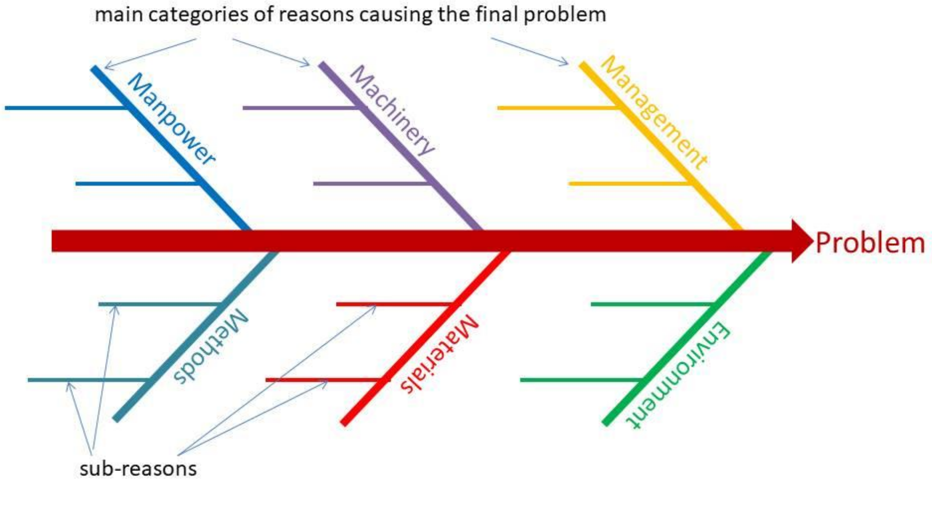

Fig. 1. Ishikawa Diagram

This tool can be easily implemented in the project based education and used for determining tasks that need to be done. In the first step, the product name should be used instead of the word "problem" in the fish head, then in next steps, main elements necessary to accomplish the project should be defined (Fig. 2). These are the ones that have to be taken into account – in the picture, they are displayed as branches of the main axis showing the 'main tasks'. Horizontal legs, marked as 'elements', will be the components of this task.

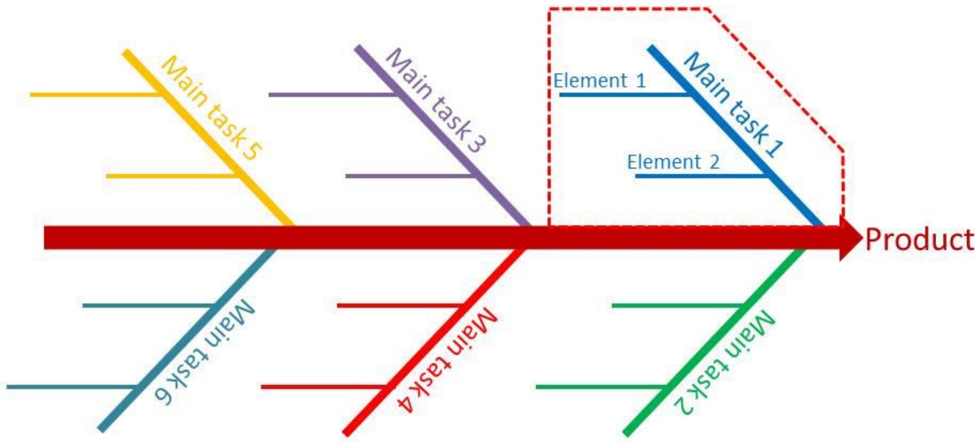

Fig. 2. Ishikawa Diagram adopted for work planning purposes in PBE

THE IMPLEMENTATION OF THE ISHIKAWA DIAGRAM WITHIN PBE

The main research objective was to verify if the Ishikawa diagram enables learners to independently plan the activities in the project that need to be done to succeed in the project. As in real project learners are expected to work and think without or with minimum teacher´s support, carrying out the research in the real project would be very difficult or almost impossible. Thus it was decided to research how the learners using the tool will manage planning activities in a hypothetical project. It was expected that if learners are able to use the tool independently, they will also be able to use this tool in working groups while working in real project.

Hypothesis

Application of the Ishikawa diagram to planning tasks in the project will allow learners to specify tasks, arrange them in the correct order and create a correct work schedule.

Description of the research tool and group

Ninety learners took part in the research. They were learners of primary and lower secondary school aged 12-16. They lived in a city of 61,000 citizens. The learners had been working with the project method before so they were familiar with it.

In order to carry out the research, the teacher shortly described the tool showing diagrams presented in Fig. 1. and Fig. 2. and told pupils how to use them. After that pupils were given a fishbone diagram on which six lines called the 'main tasks' have been marked. Each line contained from two to four branches for sub-tasks. In total, there were 20 places for sub-tasks. The learners were also allowed to draw their own branches.

Despite the fact that in the project method learners should plan further tasks and objectives in groups – they worked independently for the purpose of this research. If learners working on their own are able to use the Ishikawa diagram to plan the activities in the project, they will more probably reach success when work in groups.

Results

All surveyed learners completed the Ishikawa diagram. Seventy per cent of the surveyed learners used all six 'main task' branches in the drawing of the fish-bone. A few learners did not use all six lines and one of the learners added three extra lines. For more details, see table 1.

Table 1. Usage of main task lines. Descriptive statistics.

median	Mode	skewness	kurtosis	standard error	Arithmetic mean	minimum	maximum
6	6	-1.1	2.96	0.11	5.51	2	9

In the vast majority of cases, learners **described** the main lines (86.7 % of learners, Table. 2.). They did it in two ways:

1. They described the consecutive steps to be taken to set up a school garden (e.g. planning a garden, obtaining required permissions, collecting funds, shopping, gardening, starting party) – 68.8 % of researched learners.

2. They planned what activities they would like to implement in the garden (e.g. relaxation garden, green grocery garden, film garden, garden of experiences, etc.) and within the framework of these activities (gardens) they planned consecutive steps – 17.9 % of researched learners.

Table 2. The percentage of learners who described 1, 2, ... 6 or more main tasks lines.

Number of described main task lines	1	2	3	4	5	6 or more
Percent of learners, %	5.6	5.6	12.2	11.1	14.4	37.8

In a few individual cases (2.2 %) main tasks were also numbered from 1 to 6. Learners described their diagrams starting from the top line located next to the fish's head (first task) and ended at the bottom line also located near the head – counter-clockwise. The number of described main task lines also decreased in that direction - this is exactly what the trend line shows in the chart (Fig. 3.).

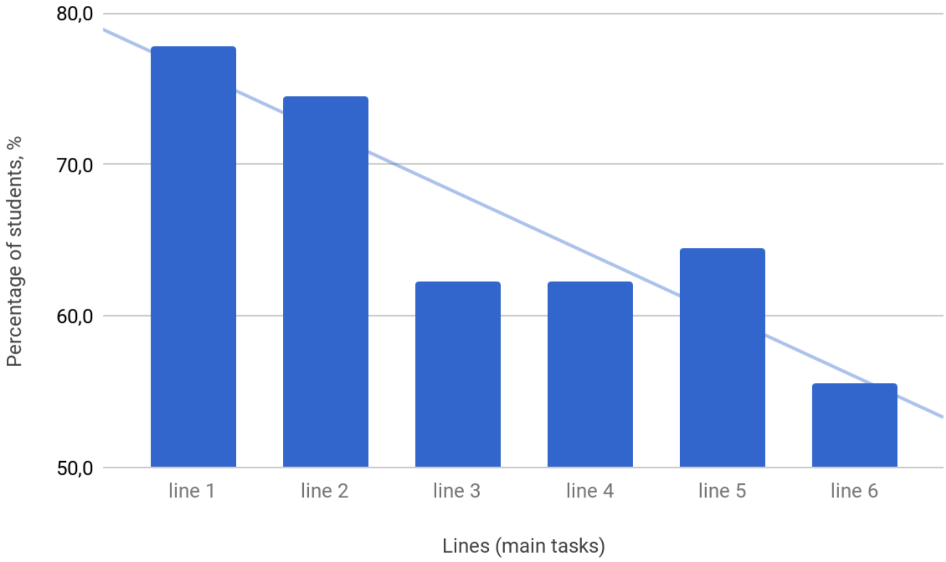

Fig. 3. Percentage of learners who described each particular main task line numbered from 1 to 6. Each line was analysed separately

After planning the main activities (called the main lines), the learners were tasked with breaking them down into sub-activities. In the diagram each main task line had spaces reserved for sub-tasks. The first branch (first main task line) had three lines for sub-tasks, the second line – four, the third one – two, the fourth one – three, the fifth and sixth ones – four lines, in total 20 items. Pupils were also allowed to add more subtasks. On average, pupils used fewer sub-tasks than they had at their disposal, in particular main lines except for branch 3 where initially they had only two lines drawn.

Looking collectively at all the branches of the diagram describing the sub-tasks, it can be seen that on average 16.1 of the available 20 branches were used (Table 3.); 11 learners (12.2 %) indicated from 25 to 54 sub-tasks. Three learners, despite descripting the main lines, did not specify further sub-tasks. One of the diagrams also contained sub-tasks dealing with sub-tasks.

Table 3. Description of sub-tasks. Descriptive statistics

Median	mode	Skewness	Kurtosis	standard error	Arithmetic mean	minimum	maximum
18	15; 18	- 1.32	5.02	0.89	16.1	0	54

IMPLICATIONS

The results of the research reveal that number of main lines learners use and describe are strongly influenced by the number of drawn main lines in a blank diagram and they rather use fewer lines than they have at their disposal (this is evidenced by negative skewness). They add extra lines only exceptionally.

Table. 4. SWOT analysis of the Ishikawa diagram in the PBE.

Strengths	*Weaknesses*
It enables to break down tasks into smaller ones, which is important especially when something is done for the first time. Moreover, it imposes to create the hierarchy of tasks (main task, subtasks ...) It allows to organise information from unordered mess, in contrast to the mind map. It allows for more precise planning of project implementation costs. It allows to minimize unforeseen situations that may affect the achievement of a beneficial project result.	There is no place for person's weaknesses - for example, someone needs more time to do something In real, the steps are not really analysed, they are written only in the schematic way. The shape of the diagram may influence on project reception by pupils and the number of tasks to be done. Compared to the Gantt chart, there is no succession of tasks or key tasks for the project – the project may not keep the timeframe. There is no way to enter checkpoints.
Opportunities	*Threats*
It increases the competence in the analysis and planning of activities, not only related to the project. It shapes job management skills, especially long-term ones.	Diagram can be too schematic for younger pupils. Revealed number of tasks to be done to conduct the project can demotivate learners.

Main task branches should be analysed separately, as a result more detailed analysis will be provided. In order to do that and to make sure that nothing is skipped, it is necessary to draw up the Ishikawa diagram separately for each of the main tasks, and for each sub-task in a more complex projects (fig. 4).

So, we can assume that main tasks that need to be completed to get a product are determined. In the next step each of the main tasks is analysed separately and the sub-tasks are identified to be done to perform this task (what its components are). In the following step, a thorough analysis of sub-tasks is suggested, indication of the other components to be done, and finally setting out what elements have an impact on the component implemented. Lowering in the hierarchy should be carried out until the elementary tasks are determined; it depends on the complexity of the project.

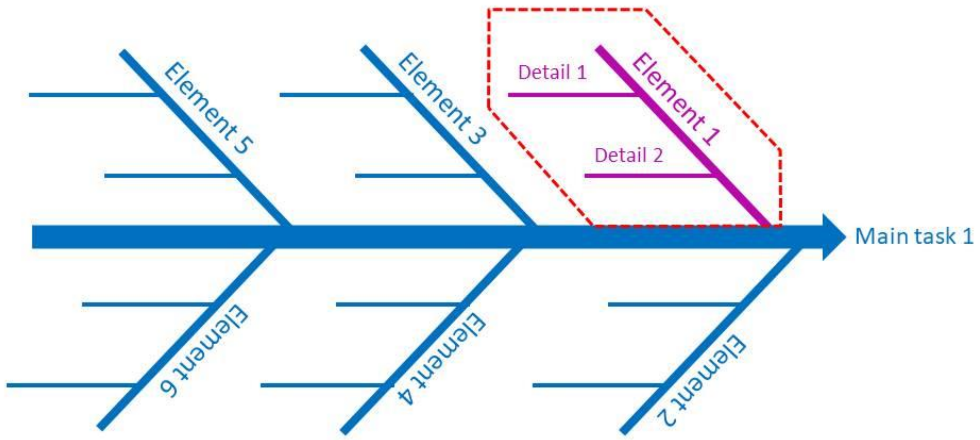

Fig. 4. Separate diagram for main task one - dashed line in the fig 2.

When all individual tasks are already laid out, they can be combined into one diagram, and ordered according to their implementation. Such ordering also enables time planning in the project. Application of the Ishikawa diagram allows to shorten the time needed for project planning and to reduce number of the necessary activities which are usually taken for planning instead of the diagram (for example brainstorming, mind mapping). In contrast to mind maps, which are sometimes used for such purposes, implementation of Ishikawa diagram follows the ordered structure of tasks.

CONCLUSIONS

The research reveals that Ishikawa diagram can be easily implemented into PBE and lower secondary school children can learn planning their work and activities to use this diagram. In a limited extent it also can be used also for time planning, however this should be enhanced by other tools. Sometimes it is easier to keep motivation for doing particular tasks when the total number of tasks is not known at the beginning. Revealing how much work needs to be done to realise the project can demotivate the pupils.

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Contact address

Dr. Paweł Cieśla[1], Dr. hab. Nodzyńska Małgorzata[1], MSc. Anna Baprowska[2], prof. PhDr. Martin Bílek, Ph.D[3],

[1]Department of Education of Natural Sciences,
Institute of Biology,
Pedagogical University of Cracow
Podchorążych 2
30-084 Kraków
Poland
e-mail: pawel.ciesla@up.krakow.pl, malgorzata.nodzynska@up.krakow.pl

[2]Faculty of Science,
University of Hradec Králové
Rokitanského 62
500 03 Hradec Králové
Czech Republic
e-mail: a.baprowska@gmail.com

[3]Faculty of Education,
Charles University
Magdalény Rettigové 4, Praha 1
116 39 Praha 1
Czech Republic
e-mail: martin.bilek@pedf.cuni.cz

WHAT DO CHILDREN DO AT SUMMER CAMPS? THE ANALYSIS OF GEOSCIENCE CAMPS' PROGRAMMES.

PRAŽÁKOVÁ Martina, PAVLASOVÁ Lenka

Abstract

This paper focuses on children and youth education realized at geoscience camps in the Czech Republic. It presents the results of a survey conducted at ten different camp sessions in 2017. Its aim is to analyse the types of the educational activities which pupils (ISCED 1-3) experience at the camps. The qualitative analysis from the instructors' point of view confirmed that both the geoscience and the interdisciplinary activities play an important role in the camps' programmes. This study might be helpful to people who decide about children and youth's free time activities.

Key words

Non-formal learning environments, outdoor education, evaluation, geosciences

INTRODUCTION

The importance of non-formal education is growing in the Czech Republic. It is due to various national strategies (Ministry of Education, Youth and Sports - see MŠMT, 2007) inspired by the current global trend of lifelong education in the 21st century. The state support brings better conditions for the work of free-time educators and subject methodologists (Papáček et al., 2015).

Prokop (2007) states that non-formal education is based on the formal one. Individual schools can cooperate with other organizations and become an active part of a public space (Rabušicová, Šeďová & Trnková, 2003). Therefore, two questions are arising. Firstly, what is the knowledge of individual people who decide about children and youth's in the field of non-formal education and if the teachers at schools are prepared to find out the needs, interests and talents of their pupils (Machů, 2010).

According to results of the national research (National Institute for Further Education; Ministry of Education Youth and Sports) summer camps belong to popular children and youth's free time activities (NIDM MŠMT, 2012). Recently, a project called Network for Science Camps in Europe, SciCamp, has drawn a public attention (SciCamp, 2015). Its main aim is the exchange of individual camps' practices and researches, their connection to various scientific institutions and the possibility to integrate the science camps into the educational systems

(Ivánková & Cibulková, 2016). However, Czech geoscience camps did not participate in this project (SciCamp, 2015).

Nowadays, there is no instrument for retaining and passing on the up-to-date information about the science camps. There is only a set of recommendations parents might use when choosing a summer camp for their children (MŠMT, 2013). Nevertheless, parents regard school and teachers as the most influential authority in the choice of child's free time activities (NIDM MŠMT, 2012).

This study deals with non-formal children and youth education in the field of non-living nature, geosciences (general geology, mineralogy, petrology, palaeontology, etc.). Individual schools (teachers, school counsellors, educators etc.) play an important consultative role when talking about non-formal education. Therefore, the key topic of this study is their general awareness of the issue. Consequently, it is people who participate in making decisions concerning the children and youth's free-time activities (educators, children and parents) who might benefit from this paper.

In the main part of the study, a qualitative research from the year 2017 is presented. This research was realized at ten camp sessions for primary, lower and upper-secondary pupils and students ISCED 1-3 (UIS, 2012) in the Czech Republic. The aim of the survey was to find out which types of educational activities pupils experience during the camp sessions. The data collection was conducted in a focus group of instructors. The tool for the data collection was a table (questionnaire prepared by the authors) covering individual camps' programmes. The results of the survey show the educational content of individual camp sessions and point out the realized geoscience activities and interdisciplinary overlaps of non-formal education.

METHODS

A qualitative approach was used for this study (Švaříček & Šeďová et al., 2007). The data collection focused on information about the programmes of the camps which offered scientific educational activities (Lindner & Kubat, 2014). The questionnaire was prepared in a form of a table, inspired by Leblecioglu et al. (2011). It was distributed at the beginning of each camp session and asked back at the end. It was only in a written form, which means that even the institutions having no official programme before the actual camp session had started, were able to submit the required data.

The geoscience camp instructors who participated in the preparation of individual camp programmes were in a selected group of respondents (n = 21). To prevent any duplicate answers in the case of identical camps, the following steps were taken. In a case of one respondent organizing more camp sessions with an identical content, only one questionnaire was filled in. Should one respondent prepare more camp sessions with different contents, they filled in one questionnaire for each session concept. In this way, the unwillingness to fill in the same programme several times was prevented too. Men predominated among the respondents (67 %) over women (33 %). As for the respondents' occupation, university scientific workers, museum staff and teachers were involved in the survey.

The data analysis was cyclical (twice in a month interval) using the method of answers' open coding process (Švaříček & Šeďová et al., 2007). The gained data were categorized, quantified and displayed in frequency tables according to the respondents' answers (tab. 2 – 4). After classifying the findings, the fundamental statements were formulated and the results were interpreted.

RESULTS

Table 1 shows general parameters of camps covered in this study. Some of the camp sessions are based on the same concept (session 3 and 4, sessions 6, 7, and 8).

Table 1. General parameters of camps covered in the study.

SESSION (N.)	DURATION	GEOSCIENCE CONTENT	ORGANIZATION
Session 1	10. – 14. 7.	mineralogy, petrology	university
Session 2	17. – 21. 7.	palaeontology	contributory o.
Session 3	16. – 22. 7.	general geology	university
Session 4	22. – 28. 7.		
Session 5	23. – 29. 7.	mineralogy, petrology	non-profit o.
Session 6	24. – 28. 7.	palaeontology	two non-profit o.
Session 7	7. – 11. 8.		
Session 8	21. – 25. 8.		
Session 9	31. 7. – 4. 8.	palaeontology	contributory o.
Session 10	12. – 19. 8.	general geology	contributory o.

These camp sessions were always held out of the school lessons. Both the outside and inside learning environments were combined. The courses were short-term, most often five days long, similarly to other European camps (SciCamp, 2015). Researched camps were either overnight camps – sessions 3, 4, 5, 10 or day-time only (suburban) – 2, 6, 7, 8, 9. Session 1 was the combination of both. Session 6, 7 and 8 were the first year of the camp. The camps were accessible to any interested participants. There was no selection (the camps did not serve as the environment for selecting talented pupils).

Categories and subcategories of individual coded units are presented in Table 2. With the basis of given categories and subcategories, a list of educational activities that pupils experience during camp sessions was created. The gained answers were either of geoscience (78 %) or interdisciplinary (22 %) character. The data were quantified and thus the absolute and relative frequencies in the instructors' answers was analysed.

Seeing Table 2 for geoscience activities, it can be stated that the most frequent activity is fieldwork (27 %). The following is active and passive work with various texts (18 %) and looking for factual information in the form of lectures and discussions (17 %). Attending geoscience expositions (be it inside or outside ones) is represented by 13 %, similarly to laboratory work (10 %). Less frequent category is collection making (7 %). Excursions is a category that puts together the answers about visiting various companies and factories. The least frequent activities which occur at the geoscience camps are watching films (3 %) and playing games (2 %) with geoscience themes.

Table 2 Identified frequencies in the instructors' responses for geoscience camp activities.

Camp activities	Frequency (n_1)	Relative frequency (%)	Frequency (n_2)
Fieldwork	66	27 %	16
Text-based activities	43	18 %	9
Gaining factual information	41	17 %	10
Attending expositions	33	13 %	14
Laboratory work	23	10 %	7
Collection making	17	7 %	4
Excursions	7	3 %	6
Watching films	6	3 %	4
Playing games	4	2 %	3
In total	240	100 %	-

Note: Symbol n_1 represents the frequency of instructors' responses in individual categories, symbol n_2 represents the frequency of instructors who gave the response (or more responses) for given categories.

When looking at interdisciplinary camp activities (Table 3) the most significant category is playing games. The games were artistic, sports or not specified. Other activities are of a minor frequency –attending indoor or outdoor expositions (9 %), excursions (4 %) and gaining factual information, only in a form of a lecture (3 %). The next table identified frequencies in the instructors' responses for interdisciplinary activities.

Table 3. Identified frequencies in the instructors' responses for each interdisciplinary activities.

Interdisciplinary activities	Frequency (n_1)	Relative frequency (%)	Frequency (n_2)
Playing games	57	84 %	12
Attending expositions	6	9 %	6
Excursions	3	4 %	3
Gaining factual information	2	3 %	1
In total	68	100 %	-

Note: Symbol n_1 represents the frequency of instructors' responses in individual categories, symbol n_2 represents the frequency of instructors who gave the response (or more responses) for given categories.

When looking at interdisciplinary camp activities (table 3) the most significant category is playing games. The games were artistic, sports or not specified. Other activities are of a minor frequency – attending indoor or outdoor expositions (9 %), excursions (4 %) and gaining factual information, only in a form of a lecture (3 %).

The overview of frequency of individual activities used at geoscience camps from the instructors' point of view is shown in table 4. According to the instructors, the most frequent activity is fieldwork (21 %) and playing (usually interdisciplinary) games (20 %).

Table 4. Identified frequencies in the instructors' responses for each educational activity.

Camp activities	Frequency (n_1)	Relative frequency (%)
Fieldwork	66	21 %
Playing games	61	20 %
Text-based activities	43	14 %
Gaining factual information	43	14 %
Attending expositions	39	13 %
Laboratory work	23	7 %
Collection making	17	6 %
Excursions	10	3 %
Watching films	6	2 %
In total	308	100 %

Gaining factual information (14 %) reaches the same frequency as text-based activities. Pupils at the camps attend expositions (13 %), work in laboratories (7 %), make collections (6 %) and make excursions to factories and companies (3 %). The least used activity is watching films (2 %).

DISCUSSION

In general, science camps are a popular activity of children and youth across Europe (e.g. SciCamp, 2015; Ivánková & Rusek, 2015; Lindner & Kubat, 2014). Since the first session in 2010, the popularity and number of special type of science camps (geoscience camps) in the Czech Republic is growing too. They are mentioned for the first time in Pražáková & Pavlasová (2017). Their development continues and in 2017 three camp sessions of a new geoscience camp were realized. Therefore, the research in this field is a new challenge. It is quite encouraging that every existing geoscience camp in the Czech Republic could be covered in this survey.

The main part of the study is based on the current need of practice in the Czech education system. According to study of National Institute for Further Education in cooperation with Ministry of Education Youth and Sports, the schools should be able to inform about the possibilities and qualities of free-time education (NIDM MŠMT, 2012). Finding out the methods of objective assessment of non-formal education is quite complicated. Despite the benefits of evaluative methods (e.g. Činčera, 2012; Ivánková & Rusek, 2015), it is difficult to apply them in every situations. That is the reason why this study has used questionnaires analysing the camp programmes from the point of view of the instructors. As Leblebicioglu et al. (2011) and Ivánková & Cibulková (2016) state, camp programmes can be presented in individual studies, but they are not usually further used, even though they should be one of the parameters parents look at when choosing a camp for their children (MŠMT, 2013).

Earth science activities are often used at the camp programmes (e.g. fossils casting, minerals collecting, excursions to quarries). However, programmes contain also interdisciplinary activities (e.g observation in botanical garden or in the zoo, attending a museum programme about prehistorical people). Interdisciplinary elements can be an important part of individual activities such as fieldwork (Esteves et al., 2015). The following discussion is dedicated to certain chosen activities.

As is clear from the results of this survey, field-based activities and games are prevailing. It is interesting that these are the activities pupils prefer at geoscience camps (see Pražáková & Pavlasová, 2017). It can be assumed that pupils who tend to participate at geoscience camps are those who are interested in the specific subject and activities (Prokop, Hornáčová & Kubiatko, 2007). The tables show an overview of activities used at science camps. It is clear that many other attractive activating methods could be implemented into the science education. These are for example problem-based learning, experiential education, cooperative learning, inquiry-based learning, project-based education (Papáček et al., 2015). As Rusek & Lindner (2016) stated, there could be the difference between the students' activity and its evaluation and the actual learning effect.

The type of the camp (overnight, day-time only or the combination of those two types) does not probably influence the type of activities used at the camps. Pupils have the opportunity to see the principles and variety of the Earth Science. This experience might be crucial for their future career choice (Carrick et al., 2016; Ivánková & Rusek, 2015). The question for future studies is to what extent pupils' affective thinking (interests, attitudes) might be influenced by changing the activities at science camps.

CONCLUSION

This paper deals with geoscience camps in the Czech Republic as a new phenomenon in a non-formal education at primary, lower and upper-secondary level (UIS, 2012). A survey in the form of a questionnaire was distributed to a focus group of camp instructors at ten camp sessions in 2017 is a part of this study. The data were analysed using a qualitative method (Švaříček & Šeďová, 2007). The results show geosciences-based (more often) and interdisciplinary (less often) characteristics of the camps. According to the responses, the most frequent activities are fieldwork and games. The less frequent ones are excursions to factories and companies and watching films. Learning and teaching at the camps combine traditional and modern forms of education. However, there is still space for more activating methods to be put into practice. It can be stated that there are no significant differences between the types of camps (overnight, day-time only, combined).

It is in the educators' interest to find out the conditions for improving the coordination between the non-formal and formal part of the education. Last but not least, it is necessary to find out how to present the existing non-formal educational activities (camps) and the indicators of their quality to the pupils' parents.

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Contact address

Mgr. Martina Pražáková, RNDr. Lenka Pavlasová, Ph.D.

Katedra biologie a environmentálních studií
Pedagogická fakulta,
Univerzita Karlova
M. Rettigové 4
116 39 Praha 1
e-mail: prazakmartina@gmail.com, lenka.pavlasova@pedf.cuni.cz

PROJECT METHOD IN NON-FORMAL EDUCATION

NODZYŃSKA Małgorzata, KOPEK-PUTAŁA Wioleta

Abstract

In Poland we’ve seen the rapid development of non-formal education. Classes in this type of education are based on the work according to the instructions provided by the teacher. An experiment was carried out intended to verify whether that young students are able to independently perform the project. The pupils had to select topic and on the basis of them create so-called graduation thesis. The successive stages of the student's thesis preparation corresponded to the next steps in the method of projects. After the work the students complete a survey, which examined the growth of knowledge, skills they have acquired in the course of the project.

Key words

Early childhood education, Experiential Learning, Non-formal Learning, Project based Learning

INTRODUCTION

In the process of student's development, apart from formal education (acquired within the school), students are also affected by very strong outside-school influences. This is not a characteristic situation only for the 21st century, although thanks to the information revolution of recent decades, this process has intensified. The following types of education can therefore be distinguished:

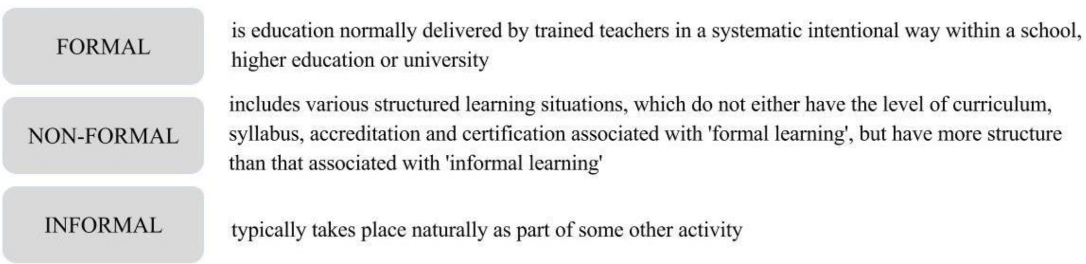


Fig. 1 Division of education

However, nowadays the change in the role and scope of formal, non-formal (Gutierrez-Perera, et al., 2016; Porumb, et al., 2013) and informal education at subsequent stages of child development can be clearly noticed, as shown in the following figure.

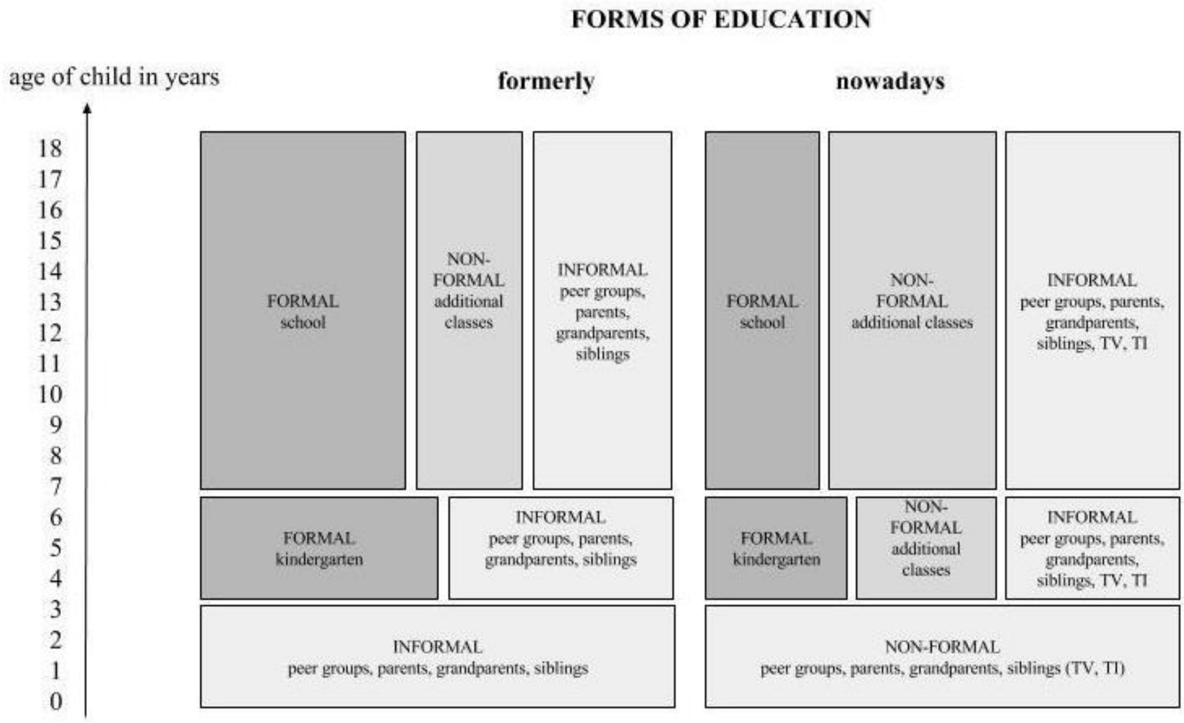


Fig. 2 Change in the role and scope of formal, non-formal and informal education at subsequent stages of child development – own study.

Currently, the offer of non-formal education is very rich, however, it seems that the Children's Universities (CU), which enjoy popularity in all Europe (www. 1-7), are of the greatest value. These are extracurricular educational activities for children, mostly aged 6-12, whose main purpose is to awaken the students' scientific passion by showing that science is a fascinating adventure. Classes conducted as part of CU are lectures by experts in a given field or workshop/laboratory classes, where students search for knowledge under the tutelage of a teacher. Due to the young age of the students (from 8 to 12 years) activities in these classes are usually based on performing experiments by students themselves according to the instructions provided by the teacher.

Review of the literature

In his publication Overton (2010) wrote: "There has been very little research undertaken into aspects of Children's Universities". Until today nothing has changed in this topic. There are research apparent related to aspects of the formation of a Children's University the study carried out by MacBeath and Waterhouse (2008) of the University of Cambridge and research on the previously mentioned Owerton (2010). Most of the publications constitute the so-called descriptions of good practice (for example, van Stam, Wahlberg, 2009) only a few publications relate to research on the effectiveness of this form of learning (Cakici, Bayir, 2012; Moskal, Nodzyńska, 2014).

DESCRIPTION OF THE EXPERIMENT

It was decided to examine whether the methods used so far in formal education (e.g. the project method) also work in non-formal education. Namely, whether students aged 8-12 know how to work independently, without the help of a teacher, and whether such independent work would bring measurable benefits regarding the expansion of students' knowledge and skills. To this end, it was proposed that students who had been attending Wadowice Children's University (WCU) classes for three years prepare an independent work summarizing the period of their learning. This work in its character was to correspond to the BA thesis written by students after the third year of study at the University. The next stages of WCU students' work on their BA thesis precisely reflected the next steps in the project method (Rusek, Dlabola, 2013).

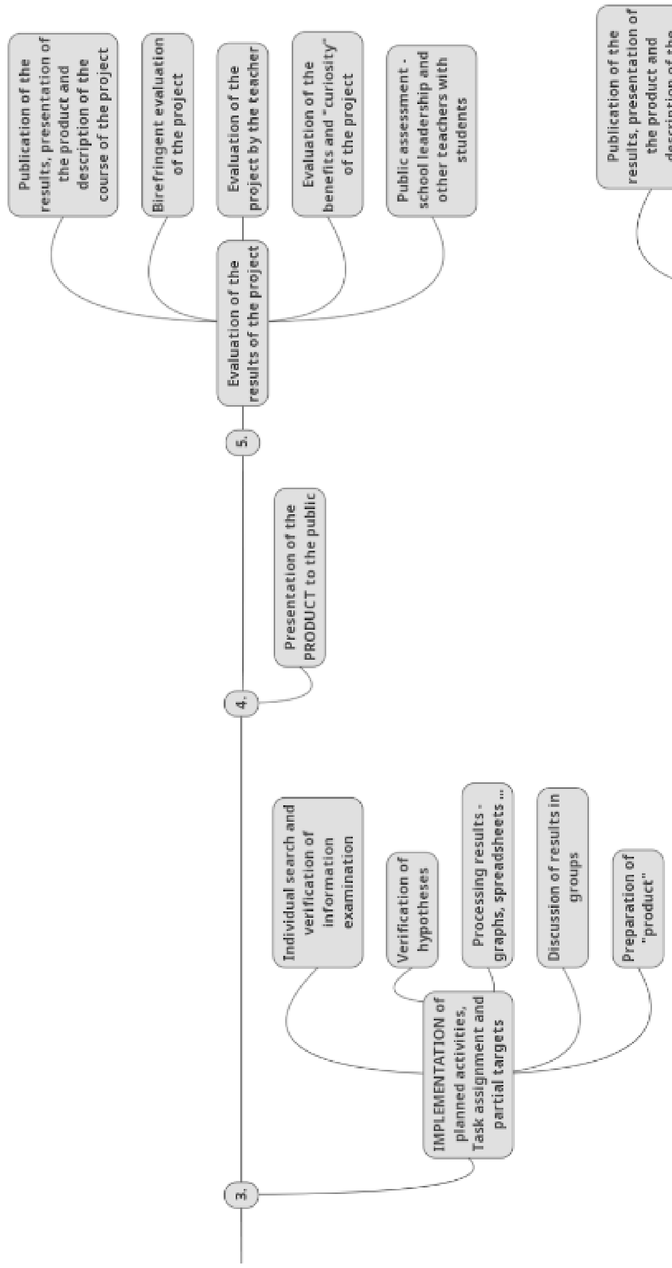
The aim BA-project is to develop profound cognition in some field of their interest, self-study competencies, critical thinking and to gain independence in the processing a research information. Until now, this type of independent activity has been studied in older students (Machkova, Bilek, 2017).

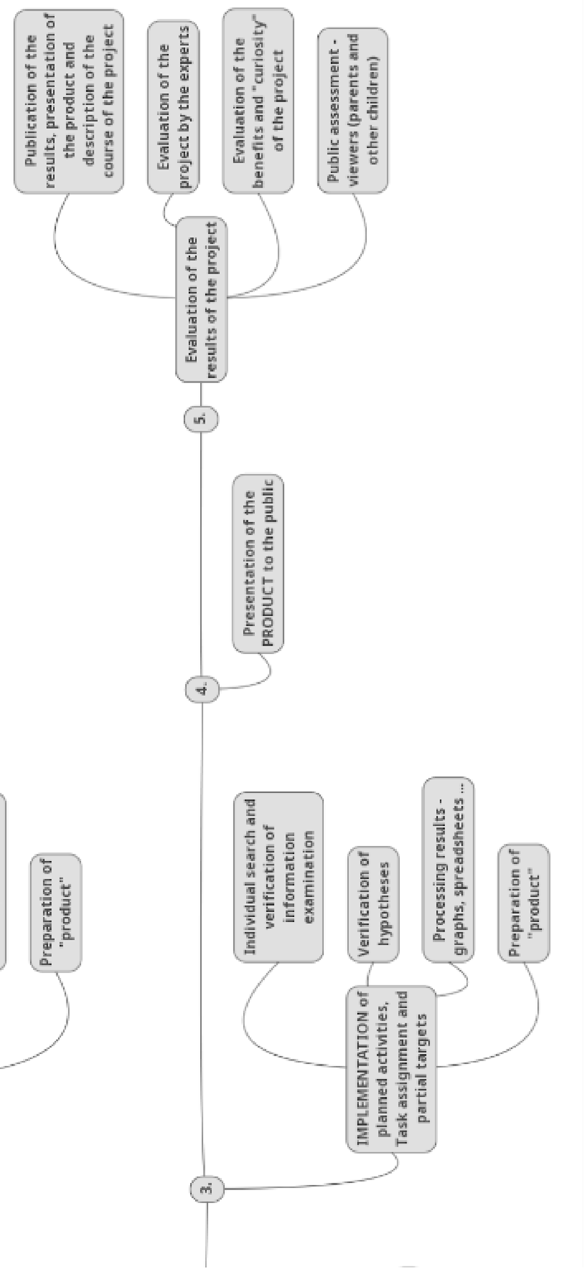
Description of the study area

Wadowice Children's University (WCU) has been run by the Wadowice cultural center (www. 8) since 2014. Wadowice is a small town, a center of pilgrimages related to John Paul II. There are no secondary or high schools in the town. WCU is attended yearly by about 120 children aged 8-12 from nearby villages and towns. For students, classes at WCU are the only window on the world of knowledge.

Goals, research methods

The **goal** of the research work was to check whether students aged 8-12 would be able to complete the project while working independently at home and also what additional knowledge and skills would be gained during the project. New knowledge and skills regarding the subject of the project as well as those that did not directly concern the topic of their work were of interest for us.


3.
IMPLEMENTATION of planned activities, Task assignment and partial targets
Individual search and verification of information examination
Verification of hypotheses
Processing results - graphs, spreadsheets ...
Discussion of results in groups
Preparation of "product"
4.
Presentation of the PRODUCT to the public
5.
Evaluation of the results of the project
Publication of the results, presentation of the product and description of the course of the project
Birefringent evaluation of the project
Evaluation of the project by the teacher
Evaluation of the benefits and "curiosity" of the project
Public assessment - school leadership and other teachers with students


3.
IMPLEMENTATION of planned activities, Task assignment and partial targets
Individual search and verification of information examination
Verification of hypotheses
Processing results - graphs, spreadsheets ...
Preparation of "product"
4.
Presentation of the PRODUCT to the public
5.
Evaluation of the results of the project
Publication of the results, presentation of the product and description of the course of the project
Evaluation of the project by the experts
Evaluation of the benefits and "curiosity" of the project
Public assessment - viewers (parents and other children)

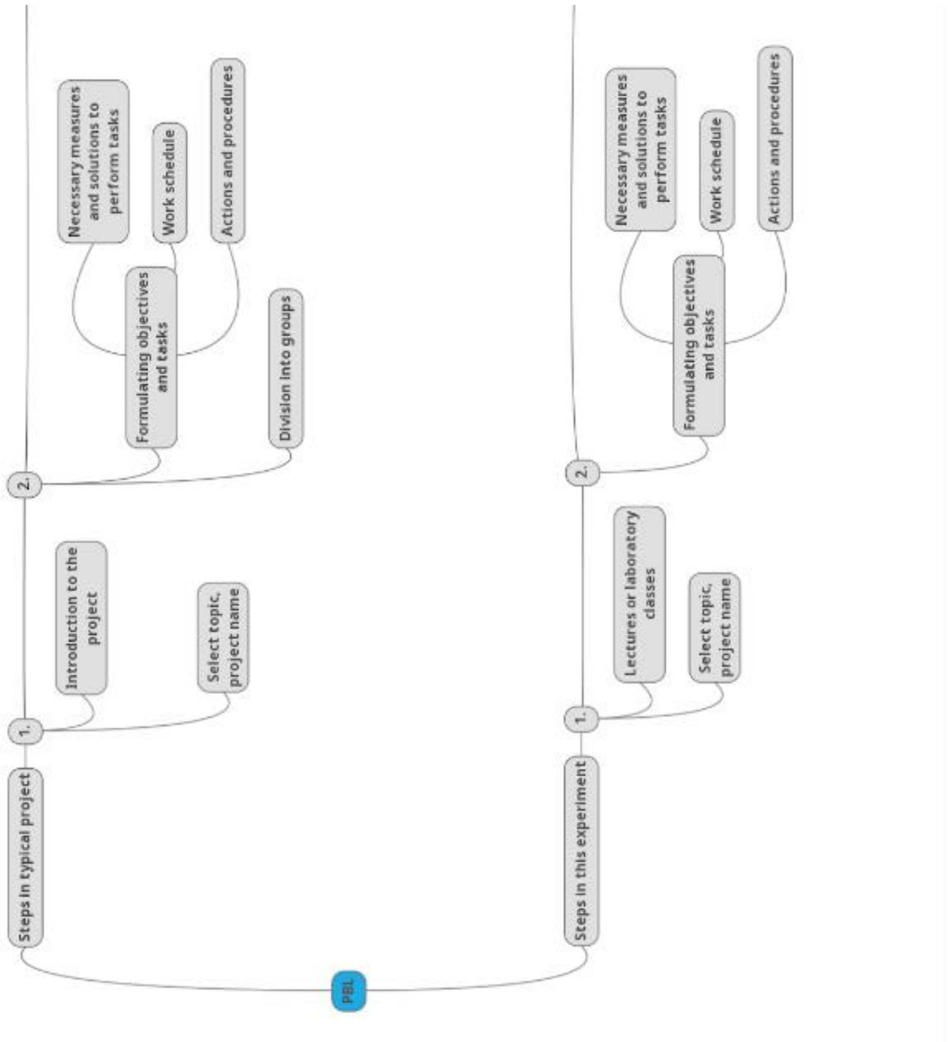


Fig. 3. Comparison of the next steps in the project method with the next steps in the preparation of the BA thesis by WCU students – own study.

A questionnaire was used as a ***research tool*** (Table 1). After the work the students were asked to complete a survey, which examined the growth of knowledge, skills they have acquired in the course of the project. Test results revealed diversity of maturity and independence in the performance of students projects.

Table 1 Questionnaire of the researcher

QUESTIONS CONCERNING THE TOPIC	QUESTIONS CONCERNING THE STUDENT
1A. Before I started my work, I knew that ... 2A. During the preparation of the work I learned that ... 3A. As I was working on my task, the following new questions appeared:	1B. During the preparation of the work I learned that (from other areas than the subject of the project) ... 2B. While preparing the work, I gained the following skills ... 3B. During the preparation of work it was

	difficult for me ... 4B. During the preparation of work it surprised me ... 5B. During the preparation of the work I was proud of ... 6B. What else would I like to learn?

RESEARCH RESULTS

At the end of the 2016/2017 academic year, 70% of WCU students (44 students) completed their BA thesis, but only 18 submitted completed questionnaires. The students did a lot of different answers to the questions because the questions in the questionnaire were open. Therefore, the questions were grouped for further analysis. However, nevertheless, the studies should be treated as qualitative rather than quantitative.

The students were aged 8-12, half of the group were girls and half boys. The distribution of age and gender in the surveyed group was consistent with the distribution in the entire population of students who completed BA theses.

The analysis of the received data shows that, when starting the project, most of the respondents (11) had basic information about the topic of their future work (see Table 2) – this is in line with the project's assumptions, WCU students were to choose the topic of work based on the topic of the classes in which they had participated in WCU. Only 4 people chose the topic that was their hobby – that is why their knowledge of the subject was very wide.

Tab. 2 Students' free answers to question 1A were classified into 5 types of answers (own study).

Before I started writing, I knew that ...	
… what will be the form of work	1
… what will be the theme and form of work	1
… daily observations on the topic	1
… basic information about the subject	11
… extensive knowledge about the topic	4

The purpose of the second question was to check whether during the implementation of an individual project, students broadened their knowledge. Various student responses were classified into 5 groups (Table 3). It can be seen that the majority of students not only significantly expanded their knowledge but also made it more detailed (9 people).

Tab. 3 Students' free answers to question 2A were classified into 5 types of answers (own study).

During the preparation of the work I learned that ...	
… refinement and extension of knowledge	9
… broadening knowledge	5
… time planning is important	2
… self-awareness	1
… no answer	1

The third question was to check whether the students performing the project focused only on solving problems and tasks related directly to their project, or they were also developing themselves scientifically by asking themselves new scientific questions. Almost all WCU students (16 people) asked themselves questions that were divided into four categories (Table 4).

Tab. 4. Students' free answers to question 3A were classified into 4 types of answers (own study).

As I was working on my assignment, I decided on new questions about ...	
philosophical question	4
general question	6
detailed, practical question	6
I did not ask any questions	2

Comparison of students' initial knowledge (answers to question 1A) with answers to questions 2A and 3A of individual students is very informative. After ascribing digital values (from 1 to 4) to students' answers, it turns out that the largest increase in knowledge was in the students with an average initial level of knowledge (in the graph: students no. 9, 10 and 11, and even higher no. 12, 13 and 14). Students whose initial knowledge was very broad and in-depth (15-18) only slightly expanded their knowledge during the project (see Fig. 4). This also applies to some students with an average initial knowledge (no. 4-8). It seems, therefore, that the project method, as a method of independent knowledge acquisition, is the best for students who already have some knowledge, but not very extensive. In the case of students with in-depth knowledge in a given field, it seems that it does not bring the expected results in terms of the broadening of knowledge from a given subject.

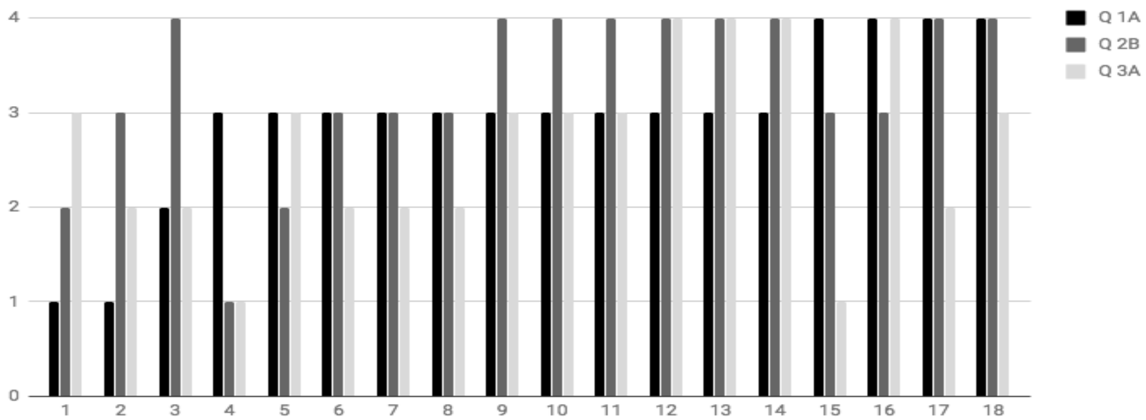


Fig. 4 Increase in knowledge during the project – comparison of answers to questions 1A, 2A and 3A.

Statistical calculations (Spearman's test) indicate a weak non-linear relationship between the answers to questions 1A and 2A (0.182) and a moderate relationship between the answers to questions 2A and 3A (0.437). Therefore, it can be concluded that the increase in students' knowledge causes the emergence of new, inquiring questions.

Since, during performing the project, students also gain skills and knowledge outside the scope of the subject of the thesis, further questions were related to this area.

And so to question 1B: *During the preparation of the work, I learned that… (from other areas than the subject)*, students gave various answers, which were classified into 7 groups: wrong answer (about the topic of work) - 4; no answer - 6; nothing - 1; time and work planning - 1; knowledge from other fields - 3; computer skills - 2; technical - 1. It can be noticed that only 7 students observed increase in their skills and knowledge unrelated to the subject of their work. It seems that the majority of students were focused on the implementation of the project and did not pay attention to what else they had learned. The lack of specific answers to this question is also due to the low self-awareness of students aged 8-12.

The answer to question 2B turned out to be slightly better: *While preparing the work, I gained the following skills…* All respondents answered this question and their answers were divided into 5 groups: preparation of presentation in PP (indicated by 5 students), writing essays (3), manual work (10), searching for information (3), time planning (1). It is noticeable that the first three of the abovementioned skills were directly related to the technique of performing work. Only the last two skills (searching for information and time planning) were general skills, useful in every project.

Answering question 3B: *During the preparation of the work, it was difficult for me…*, the students pointed to various aspects of the work, which were grouped into 7 categories: selection of information (5 answers), acquire materials and arrangement of the work plan (1), time planning (1), understanding of information (1), technical side of preparation work (6), nothing (2), no answer (2). Among the given responses, two can be distinguished: material selection and technical side of the project. The skill of material selection seems particularly useful in further education.

Questions 4B and 5B concerned the emotions experienced by students during the project. And so the answers to question 4B: *During the preparation of the work, it surprised me...*, were classified into 8 types of answers: how well I dealt with it (4 answers), there are so many places to get information (1), how many messages can be found on the Internet (1), technical side of preparation work (1), how much patience must be put into it (2), wrong answer (about the topic of work) (4), nothing (1), no answer (4). However, as it can be seen, the students did not experience 'creative anxiety' during their work on the project.

Answers to question 5A: *During the preparation of the work, I was proud of…*, were classified into 6 groups: concrete - broad answer (8 answers), I did the job (5), I gained new knowledge (1), I invented designe work (1), the time I did the job (1), no answer (2). As results from the answers, in most cases the students were proud of their work and were able to describe it clearly (8 people).

The last question (6A) in this series: *What else would I like to learn?* divided the students: 8 of them listed specific knowledge and skills that they would like to possess, while the other 8 students wrote: "many things can not be listed". 2 students did not answer this question. Therefore, it can be stated that for at least 8 respondents, the project became the starting point for further scientific research and in the other 8 students it showed how many interesting problems there are still to be solved.

Discussion of results

The students' answers to question 1A show that only 4 people treated the BA project as an opportunity to present their previously acquired knowledge. For other students (12) BA-project was an opportunity to broaden their knowledge (understood here as informations, skills and attitudes). The results of the research (question 2A) show that the task has been fulfilled - 14 students have expanded their knowledge. Work in the BA project has also become a basis for students to pose new, scientific questions, both philosophical and very general, as well as practical or detailed. The correlation between the answers to questions 1A, 2A and 3A allows the thesis that the BA-project brings the most benefits to students who have 'average' knowledge about this subject. Further, detailed studies of this relationship are planned.

During the BA-project, students also acquired 'soft' competences and could expand their knowledge from other fields than the subject of their project. However, it seems that the young age of students makes it difficult to explore this area (compare answers to questions 1B and 2B). Also, the technical difficulties with the implementation of the BA project have obscured the acquisition of other competences (3B). Questions 4B and 5B also seem too difficult for students of this age. They require self-awareness, which is not so 'young researchers'. Although the students did not notice the increase in knowledge (see answers to questions 1B-5B), but their answers to question 6B show that it is not true. Answering the question "What else they would like to know ..." 8 students give specific, detailed answers. These answers are not related to their main topic of research. This shows that although pupils do not realize the acquisition of new knowledge, not related to the subject of the BA project - they have acquired such knowledge.

Analysis of students' answers to questions - shows how difficult task is to study the increase in knowledge (understood here as informations, skills and attitudes) in students during the project implementation. We must take into account the students' initial knowledge and examine what, apart from the subject of the project, the pupils have learned. In the case of children aged 8-12, who lack self-awareness, this is a very difficult task.

SUMMARY

The research results discussed above show that the project method (applied in formal education among 12-14 year old students in Poland) will also prove useful in non-formal education in students aged 8-12. This independent work brought tangible benefits regarding the expansion of both knowledge and skills of the students, however, it mainly concerned students who had already had some knowledge – but not very extensive. Students having extensive and detailed knowledge about the chosen topic at the beginning of the project did not broaden it to a significant degree. Although the students had problems listing what they additionally learned during the project, it was noticed that 6 students had listed time planning as an important skill while answering various questions, and 9 students had listed searching for information and its selection. Therefore, it can be concluded that the project has not only influenced the students' knowledge, but also increased their soft skills. For the vast majority of students, the project also became the beginning of further scientific research as new questions arose during the project. Therefore, it can be concluded that the application of the project method in non-formal education has fulfilled its role and the WCU students will also prepare their BA theses in the following years.

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Contact address

Dr. hab. Małgorzata Nodzyńska[1], Mgr Wioleta Kopek-Putała[2]

[1]Department of Didactics of Natural Sciences
Pedagogical University of Cracow
Podchorążych 2
30-084 Kraków, PL

[2]Department of chemistry
University of Hradec Kralove
Rokitanského 62
500 03 Hradec Králové, CZ

SKILLS OF PRE-SERVICE BIOLOGY TEACHERS TO SOLVE AN INQUIRY-BASED TASK

PAVLASOVÁ Lenka, JANŠTOVÁ Vanda, LINDNER Martin

Abstract

Inquiry-based education can increase pupils' motivation to study biology and improve their achievements. Its implementation depends on teachers' ability to solve and teach solving such tasks. We describe skills of pre-service biology teachers: 1) setting research goals, questions, hypotheses; 2) reading and reasoning results. The answers were qualitatively analysed. Formulating a hypothesis was shown to be more difficult than formulating a goal and a question. Correct formulation did not always lead to correct answer. Pre-service teachers were better at reading and reasoning the results.

Key words

inquiry - based teaching, inquiry - oriented learning, teacher preparation

INTRODUCTION

Requirement for inclusion of inquiry-based education is based on its potential to increase pupils' motivation to study biology and their achievements. It is recommended to start with guided inquiry which is preferred by the students to open-inquiry labs as they feel they learn more with guided-inquiry labs as beginners (Chatterjee, Williamson, McCann, & Peck, 2009). Successful implementation of inquiry-based tasks in teaching is of course dependent on teachers' ability to solve and consequently teach solving such tasks. If a teacher does not have the experience of solving inquiry problems alone it is hard to assume that this skill will be learned by his or her pupils. If we want to teach students and pupils critical thinking and inquiry, we have to start with pre-service teachers. Universities preparing future teachers are paying different attention to the development of this skill. Windschitl (2004) points to the fact that those who eventually used inquiry during their teaching were those who had significant research experience. It has been shown that Czech pre-service teachers are mostly not familiar with research and its processes, as seen from the analysis of their theses (Janštová & Novotný, 2017). Eick & Reed (2002) note inquiry-oriented teaching might be easier to adopt by a predisposed teacher. Nevertheless we should prepare all pre-service teachers for inquiry-oriented teaching.

The ability of teachers to apply inquiry in teaching depends to a large extent on their personal interest to learn this teaching conception. If a teacher believes successful science learning was enculturated into scientific practices he/she uses inquiry-based labs extensively to teach the practices of science (Wallace & Kang, 2004). Teachers can learn more in further education courses (McDermott, Shaffer & Constantinou, 2000), gain information from publications with methodical guides for teachers (see e.g. Janštová, Pavlasová, & Černý, 2014; Pavlasová, 2016; Pavlasová & Janštová, 2017) and from the internet (Pavlasová, 2014).

A lot of published research articles deal with the beliefs, perceptions and practices of inquiry of science teachers (Luft, 2001; Brown & Melear, 2006; Taylor et al., 2008). Less of them are focused on the level of their readiness to teaching this way (Roth, McGinn, & Bowen, 1998), which is also the topic of our study. Roth et al. (1998) have shown that pre-service teachers are not using their background in science and argue the same way 8th grade pupils do rather than scientists.

Teacher can develop pupils' abilities through inquiry-based tasks in different phases of inquiry cycle (Pedaste et al., 2015), he/she should be familiar with all of them. In the present study, we focused on two phases, conceptualization and investigation (according to Pedaste et al., 2015). Goal of the study was to find out level of skills of pre-service biology teachers at the end of their studies in two stages of research work: (1) setting research goals, research questions and hypotheses, (2) reading and reasoning experimental results.

METHODOLOGY

Participants of this research were pre-service biology teachers (*n* = 26) from the Czech Republic (two faculties of Charles University educating pre-service teachers; 7 students of Faculty of Education, referred to as S1 - S7 in this text; 8 students of Faculty of Science, S8 - S15) and from Germany (Martin Luther University, 11 students, S16 - S26). Students were in the last year (last semester) of their studies after completing all courses of didactics of biology and pedagogical practice. The students were studying different combinations of biology and other subjects or just biology.

Students were given a work sheet with 6 tasks (each task contained two partial questions) and colour picture of electrophoresis results (see appendix). Assignment of the task was based on Pavlasová & Janštová (2017). It was written in the students' native language, in case of German students in English with German translation. First, students fulfilled tasks 1 – 3 and after finishing and submitting them they fulfilled the remaining tasks (4 – 6). The time for the solution was not limited. Tasks 1 – 3 were focused on setting research goals, questions and hypotheses; tasks 4 – 6 on reading and reasoning results. All tasks were open-ended, required the production of a free response by students and had more possible solutions.

For data analysis, a qualitative approach was used. As each task contained two partial questions, in total 12 answers were evaluated for each student. The evaluating scale had four variants: correct answer/incorrect answer/missing answer/illegible answer for all questions. At first, each answer was evaluated individually by two members of research team, the results were compared and discussed in the case of disagreement. The final decision was made afterwards. The agreement between the two evaluators was very good, a different evaluation was recorded in 0.05 % cases. In describing the results, frequencies and relative frequencies supplemented by examples of students' answers were used.

RESULTS

The students answered all the tasks in approx. 30 minutes, spending most of the time formulating the research goal, research question and hypothesis. Table 1 shows the success rates of formulating the research goal, research question and hypothesis (tasks 1 – 3).

Tab. 1 Number of students with at least one correct answer to tasks 1 – 3 (focused on research goal, research question and hypothesis). Abbreviations: UK/FE Charles University, Faculty of Education; UK/FS Charles University, Faculty of Science; MLU Martin Luther University; abs. absolute; rel. relative; freq. frequency. Source: authors

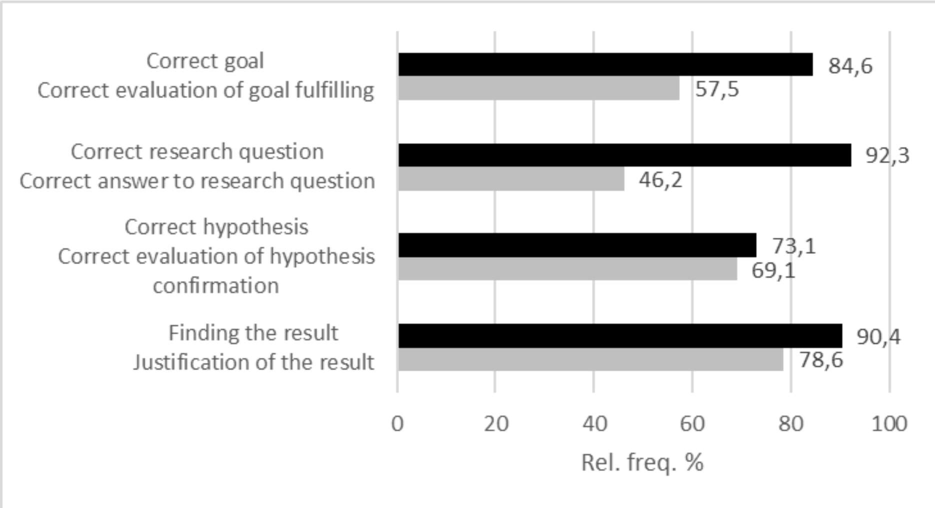
University/faculty Parameter analysed	UK/FE (*n* = 7) Abs.|rel. freq. (%)	UK/FS (*n* = 8) Abs.|rel. freq. (%)	MLU (*n* = 11) Abs.|rel. freq. (%)	Total (*n* = 26) Abs.|rel. freq. (%)
Correct goal	7 | 100	8 | 100	7 | 63,4	22 | 84,6
Correct evaluation of goal fulfilling	3 | 42,9	8 | 100	4 | 36,4	15 | 57,7
Correct research question	7 | 100	8 | 100	9 | 81,8	24 | 92,3
Correct answer to research question	2 | 28,6	8 | 100	2 | 18,2	12 | 46,2
Correct hypothesis	6 | 85,7	6 | 75,0	7 | 63,6	19 | 73,1
Correct evaluation of hypothesis confirmation	5 | 71,4	6 | 75,0	7 | 63,6	18 | 69,2

Some students formulated more (correct) research goals as there were more possible correct answers (see Methodology). Four students formulated two correct research goals. For example the goal: „Find out molecular weight of milk proteins in different milk types.“, (S3) was considered correct. Incorrect goal was formulated by four students, e.g.: „To reason the (wide spread) cow milk allergy.“ (S5), as such a goal cannot be fulfilled based on the electrophoresis. All the stated goals were evaluated correctly, but ten students did not evaluate the goal they stated. There were students who formulated more than one research questions as well. Five of them stated two correct research questions, two students stated three, one student stated four and another one five correct research question. A correct research question was e.g: „What is the representation of proteins in different milk types?“, (S20). In total, eleven incorrect research questions were stated, one student did not answer and one answer could not be analysed because it was illegible. The mistakes were factual, not formal in the case of research questions (e.g. „What is the most common alergen?“ S19; “How many 1-6 years old individuals are allergic to milk?“, S25). Number of correct answers to research questions was the lowest, mostly due to respondents from pedagogical faculties (faculties of education). Two respondents formulated three correct answers, one formulated five correct answers (e.g. „There are proteins with molecular weight 25 a 37 kDa in oat milk.“, S10). Only three answers were wrong (e.g. „The proteins with the biggest molecular weight are in soy milk, the ones with the smallest in rice milk.“, S5). Thirteen students (one half) did not answer, one answers was illegible. Six students formulated two correct hypotheses, three students three correct hypotheses (e.g. „There are differences in protein content between animal and plant milks.“, S12). Seven hypotheses were incorrect, one illegible, two students did not state any hypothesis. The incorrect hypotheses were either formally badly formulated (e.g. as a description of work done, S3; as a question, S14 and S25) or it was not possible to analyse them based on the experiment presented (e.g. „The more proteins the milk contains, the more allergenic it is“, S19). When the hypothesis was formulated correctly it was mostly evaluated correctly (table 1). See table 2 for frequencies of answers to tasks 4-6, reading and reasoning results.

Tab. 2 Number of students with correct answer to tasks 4 – 6 (focused on evaluating and justifying test results). Abbreviations: UK/FE Charles University, Faculty of Education; UK/FS Charles University, Faculty of Science; MLU Martin Luther University; abs. absolute; rel. relative; freq. frequency. Source: authors

University/faculty Parameter	UK/FE (*n* = 7) Abs. | rel. freq. (%)	UK/FS (*n* = 8) Abs. | rel. freq. (%)	MLU (*n* = 11) Abs. | rel. freq. (%)	Total (*n* = 26) Abs. | rel. freq. (%)
Task 4 – correct solution	7 | 100	8 | 100	8 | 72,7	23 | 88,5
Task 4 – correct reasoning	6 | 85,7	8 | 100	5 | 45,5	19 | 73,1
Task 5a – correct solution	7 | 100	7| 88,0	9 | 81,8	23 | 88,5
Task 5b – correct solution	7 | 100	8 | 100	9 | 81,8	24 | 92,3
Task 6 – correct solution	7 | 100	8 | 100	9 | 81,8	24 | 92,3
Task 6 – correct reasoning	6 | 85,7	8 | 100	8 | 72,7	22 | 84,6

The tasks 4, 5b, 6a, 6b were only answered correctly or not at all (with one illegible answer). One student reasoned task 4 (recommend a suitable substitution for cow milk for people with cow milk protein allergy) incorrectly („A suitable substitute is soy milk which contains a big percentage of proteins“, S5). One student solved task 5a (recommend a milk suitable for high protein content diet) incorrectly („Coconut milk – big amount of proteins in low concentration“, S10). Summary of all results is in graph 1.



Graph 1. Summary of total results. Finding the result: means from tasks 4a, 5a, 5b, 6a. Justification of the results: means from tasks 4b a 6b. Abbreviations : rel. freq. % relative frequency in %.

DISCUSSION AND CONCLUSION

As Roth et al. (1998) pointed out, the pre-service teachers' reasoning can be closer to pupils' one rather than to the desired scientific reasoning. We surprisingly found that correct formulation of a research goal / research question / hypothesis did not always lead to correct answer. Clearly, not all pre-service teachers understand the connection between formulating a research question and answering it which is true for setting a research goal as well. Formulating a hypothesis was more difficult than formulating a research goal and a research question which is in concordance with our teaching experience. But when a hypothesis was formulated, it was mostly answered correctly.

This probably shows students do not formulate a hypothesis unless they are sure they do understand the rules of it. Pre-service teachers were better at reading and reasoning the results. This is in concordance with Banchi & Bell (2008) showing the (university) courses are more often aimed at structured and confirmation inquiry which is a good option of inquiry for the start and is preferred by students (Chatterjee et al., 2009). We also found pre-service biology teachers from Faculty of Science were more successful in stating research goals and questions which is in concordance with the fact they use more statistical methods in their final theses (Janštová & Novotný, 2017) and presumably have more research experience which is recognised as crucial by Windschitl (2004).

Although it is a fact a teacher has to formulate properly in order to teach it to the pupils, we are not sure how much will the pre-service teacher use what they know about inquiry in their future teaching. To support the pre-service teachers do use what they have learned about inquiry, we should show them scientific inquiry is important for learning science (Wallace & Kang, 2004) and should practice inquiry with all pre-service teachers despite their possible predispositions recognised by Eick & Reed (2002). The results will be valuable for modification of courses for pre-service teachers using inquiry.

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Contact address

RNDr. Lenka Pavlasová, Ph.D.[1], RNDr. Vanda Janštová, Ph.D.[2], Prof. Dr. Martin Lindner[3]

[1]Department of biology and environmental studies
Faculty of Education,
Charles University
Magdalény Rettigové 4
116 39 Praha 1
e-mail: lenka.pavlasova@pedf.cuni.cz

[2]Department of Education and Didactics of Biology
Faculty of Science
Charles University

Viničná 7
128 43 Praha 2
e-mail: vanda.janstova@natur.cuni.cz

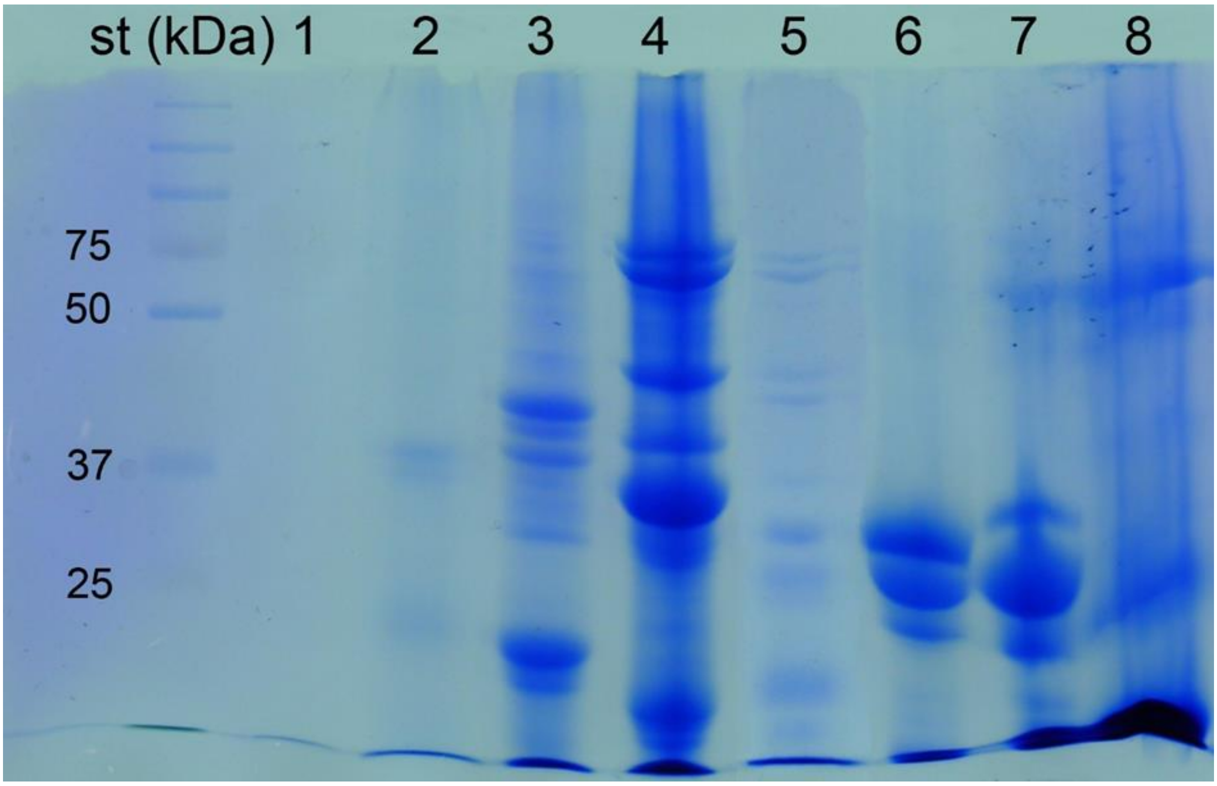
[3]Department of Biology / Geography Education
Martin-Luther-Universität Halle-Wittenberg
Biologicum, Weinbergweg 10
06099 Halle
e-mail: martin.lindner@biodidaktik.uni-halle.de

Appendix

Milk allergy

Read the text and have a close look at the picture first. Solve the following tasks afterwards.

Our diet basically consists of sugar, fat and proteins. All these three components are essential for our body. Proteins are also the most effective allergens. Cow milk allergy is relatively common. It occurs in 1 to 3 % kids under 1 year of age. When treated appropriately, the allergy usually disappears in 50 % of patients during the first year of life and in 90 % of patients before 6 years of age. We can sometimes observe so called cross-reactivity between milk proteins from different animal species like goat, buffalo, mare or camel. Dividing the proteins by their shape and size using electrophoresis can help us to imagine protein content and composition in different milks and plant „milk“ drinks. The proteins are visualized by a dye. The size can be determined by comparing the position of the protein with a position of size standards, proteins with known size. An example of such proteins electrophoresis of different milks and plant „milk“ drinks is on picture 1 below. All the samples used for the electrophoresis have similar volume.



Picture 1. Samples of different animal and plant milks and a food supplement made of whey proteins. Samples: 1 rice milk, 2 oat milk, 3 almond milk, 4 soy milk, 5 coconut milk, 6 cow milk, 7 goat milk, 8 whey protein mixture. St (kDa) - molecular weight standards (kDa is an atomic mass unit).

Use the text and picture above to answer the following questions:

1. What is likely to be the aim(s) of the researcher who performed electrophoresis in the setting described above? Was he/she successful?

2. Formulate research question(s) which the researcher wanted to answer. How did he/she answer the research question(s), based on the experiment described above?

3. Formulate hypothesis/hypotheses which was the researcher testing. Did he/she confirm or falsify it/them? Write down the reasons for confirming of falsifying each hypothesis.

4. Based on electrophoresis results, recommend a suitable substitution for cow milk for people with cow milk protein allergy. Give reasons for your answer.

5. Recommend a milk suitable for a) high protein content diet, b) low protein content diet to your schoolmate. Assume each sample on the picture has similar volume.

6. Which type of milk is likely to be the least allergenic? Give reasons for your answer.

UPPER SECONDARY SCHOOL STUDENTS´ MOTIVATION TO PARTICIPATE IN RESEARCH PROJECTS

FABRYOVÁ Anna, JANŠTOVÁ Vanda

Abstract

It has been shown project based education is one of the possible ways to motivate pupils toward science. Therefore, we tried to find out what can bring upper secondary school students to participating in voluntary after school science (biology) projects. Eight upper secondary school students were interviewed about their motives, feelings and impact of the project on their future studies. Each participated in a science project no longer than three years ago (with an exception for pilot study). All students appreciated the participation which changed the image of science and scientist for them.

Key words

Higher Education, Informal Learning, Motivation, Practical Work in Science, Project based Learning

INTRODUCTION

In recent time, upper secondary students´ interest in science has been decreasing (White Wolf Consulting, 2009). This trend should be an alert for teachers and teacher educators to change the approach to motivating students towards science subjects as it is science at school what can attract pupils to choose scientific careers (Osborne, Simon, & Collins, 2003). Apart from the teachers and quality of the science subjects at school, the popularised science is another factor attracting students towards the science career (Christidou, 2006). Janštová & Rusek (2015) bring an overwiev of possible methods motivating students toward science and mention project based learning. The suitability of project based learning for different types of students, including those already intersted in science, is also discussed by Lindner (2014) and Rusek & Lindner (2017). Based on these findings we interviewed upper secondary students who participated in an after school science project in Czech Academy of Science, at a university or in a private research company, to clarify their motives to attend the project, their general idea about science and scientific jobs and their idea of their future career.

METHODOLOGY

Because we were searching for motives and feelings of individual respondents with long term science projects experience we used qualitative approach, semi-structured interviews and open coding. Names of the respondents were changed.

Respondents of the study

The respondents, upper secondary school students with experience with long term science (biology) projects, were addressed by their biology teachers or project tutors and asked to participate in the study. We contacted and instructed the teachers, tutors and organisers to find the potential participants.

Our request was that the students participated on a science project which lasted at least few weeks not longer than three years ago (with an exception for a pilote study), was supervised by a professional and the students themselves participated in finding the project.

Eight respondents replied to our request and became part of this study, Table 1.

Table 1 – Overview of study participants.

Respondent	Gender	Years after finishing the project	Project location	Field
Kamil (P)	Male	8	Academy of Science	Microbiology
Čeněk (*)	Male	0	Academy of Science	Microbiology
Pankrác (*)	Male	0	Academy of Science	Microbiology
Josefína	Female	1	Academy of Science	Botany
Alois	Male	1	Faculty of Science (Charles University)	Parasitology
Libuše	Female	3	Academy of Science	Botany
Bořivoj	Male	0	Academy of Science	Nanotechnologies
Amálie	Female	1	Private sector	Molecular biology

*P – pilote study, * - participants of group interview (with 2 respondents at the same time)*

Interviews and data analysis

Semi-structured interview was used to obtain the data. A set of questions was prepared (documenting five topics – basic information about project, project participation, interest in science, science education at school, future career choices), but their order was not fixed. Open questions were used so the participants could answer them using their own words. Also, new questions and topics could appear during the interview and the respondents were not time limited. They were interviewed during separate meetings in a calm place (e.g. a café). The interviews were recorded after signing the informed consent and its' duration varied from 25 to 80 minutes. Two interviews occured under modified conditions. In the first, two respondents were interviewed at the same time. In the second, an on-line interview was performed using social media. Recorded interviews were transcribed and the transcripts were open coded.

In the following text, quotes of the exact transcripts with the author mentioned are used.

RESULTS

Based on the coded text and the code categories, following topics were discussed the most during the interviews or brought interesting results.

Interest in science

Respondents were interviewed about factors which could initiate their interest in science and scientific subjects. All of them mentioned some influences from their childhood such as reading scientific books, watching documents, taking care of plants, etc.

> *I like plants the most… it has been like that… since I bought my first cactus.* (Libuše)

Students' motives to participate in science projects

Many respondents were brought to choosing scientific project by their need to do „something extra“ for their school work (typically they did a final or seminary thesis).

> *And we…found out, we could write some, some kind of… final thesis, which could be… of some reasonable value.* (Pankrác)

Many of them wanted to give it some „added value“ by working on the thesis with field specialists from outside the school, or intended to apply for a student contest with it (e.g. SPA – Students' Professional Activities).

> *And of course I wanted some… some interesting project, which could be evaluated well… or I… I could be succesfull with in SPA.* (Alois)

For majority of the respondents, it was important to get experienced in the field which interested them for their intended future study.

> *I expected to… mainly to learn something, to get the experience of how science is really done. So I… I was really happy to… to try the real work of a true scientist I believed to become in the future.* (Alois)

Teacher's role

We also focused on how science is presented and taught at school and how much this influnced students' interest in it. The results show that many students were influenced positively towards science by their school teachers, mostly by his/her own interest and excitement about science or by lessons full of practical learning.

> *We got a really great physics teacher. He has just graduated and was fully enthusiastic about his subject, so we did a lot of experiments. And he was always excited to hear right answers to his questions. That motivated me a lot and I started enjoying physics because of him.* (Bořivoj)

Interestingly, students did not appreciate only teachers' excitement and lessons full of fun, but also needed a complex structure of the classes, clear orders and instructions. They even found it motivating when the teacher was strict, but fair, with natural authority.

> *It was caused by many factors (that the geography teacher was not popular). She tried to be very interactive… we worked a lot with the book of maps, she brought us some extra sheets with tasks… and she definitely knows a lot about her field, but… she was not really succesfull to create a respect and… the geography lessons were more like a chaos.* (Pankrác) … *Exactly. I mostly regretted that teacher.* (Čeněk)

Students also evaluated well when the teachers supported them in attending students' competitions (e.g. field olympiad).

> *In 9th grade my teacher nominated me for this chemical contest and… we were both surprised when I proceeded (laugh). So she started to give me extra lessons in the afternoon and… that was a big impuls for me on the science field.* (Amálie)

On the other hand, there were also respondents who did not feel supported by their teachers towards extra activities, or they even critised the way science subjects were taught at their school generally.

> *I was really sorry we did not have any… practicals during our biology lessons. We had maybe… one lesson like that… where we really used microscopes to observe plant material and other thimgs.* (Josefína)

Impact of science project on future study and career

All respondents were asked about impression they got from participating in the project and how it influenced their opinion about the scientific field. Further question was: Did the project meet your expectationts about how science is done and about being a scientist? All the participants evaluated their project as beneficial because it showed them science with it's specialised scientific fields and sometimes even helped to put together various knowledge they got at school with the advanced information they learned during the project and with the practical science.

When I finally understood what is going on… on the gel… what is actually hapenning there. That was a… a big moment of… I know why it is done like that! (Libuše)

By experiencing the work of a scientist during the project, some respondents confirmed their future study choice.

For sure (the science project) made me sure it is worth it. Because… I enjoyed it very much. … I feel I will definitely try to get somewhere I want next year (study science at university). (Amálie)

Experiencing the project and finding out what science really is about, made some of the respondents change their mind about their future career.

Maybe I would still be willing to do microbiology or some other research, because my image was different from the reality. Therefore I think the impact (of the project) was crucial. I decided to do medicine instead. (Pankrác)

DISUSSION

Many factors were shown to have an influnce of students' interest towards science e.g. watching scientific documents or reading books about science. Also some long-term hobbies like growing plants had influence. Most of the students were premotivated as described by Rusek & Lindner (2017).

Students' motives to participate in science projects

Participating in the science project outside of school was caused by both internal and external motivation. Usually, the first impulse was external (e.g. demand to write a thesis), but that one never occured by itself alone. It was always followed by inner motivation (to have a valuable thesis, with specialised practical part) as without these inner motives, students could also write a simple thesis, supervised only by their school teachers. We also understand the desire of students to experience doing science themselves, to know the conditions of the scientific field, where they would like to work in future, to know the daily work of a scientist, whom they would like to become one day as internal motivation. Not only desire for knowledge or an interest in particular fields or topics motivated the students to an extra study performance.

Extermal motives are also important as found also by Miserandino (1996). It can also be a desire to compare themselves with other peers and get some appreciation in form of attending student contests or professional discussions.

> *And one of the best benefits was… the performance and presenting itself... with the results and the thesis itself. I participated in the Summer school of the SPA, where… all of us were the contestants and… we commented on each other's thesis, discussing it, etc.* (Alois)

Teacher's role

We were also interested in teacher's influence on students' attitude towards science subjects. We found this was based on teachers' abilities to present the facts in class and make the lessons interesting together with being strict but fair. Similar finding was made already by Witty (1947). But apparently, students coming from a less motivating school background applied for science projects as well. Experience of these participants was even more intense, because sometimes they met practical science for the first time.

> *I learned how to use lab tools properly. Until then I couldn't imagine it, based on what equipment do we have in our school lab.* (Josefína)

Impact of science project on future study and career

The scientific project significally influenced the conception of science and how it is really done as well as what does it mean being a scientist. Before attending the project, the idea of a scientist was quite stereotypic, an old man with ruffled hair, running excitedly in his lab coat and performing exciting experiments.

> *Mmm, I had an image of scientist in my mind… a guy in a coat, with bulb in his hand and… I think I couldn't think of him any other way.* (Alois)

This kind of image is also mentioned by Archer et al. (2010), for review see Finson (2002). This idea was modified or completely changed after the practical experience with real science. A lot of students considered their work interesting, but also quite repetitive. They were also surprised how much time regular scientist spends by the computer analysing the data or doing necessary paperwork.

> *Well… I found out that… being a scientis isn't just experiments, but… also a lot of other things to do… grant requests… search for fundings, material. And… somehow the guy in the lab coat turned into somebody sitting by the computer (laugh.).* (Alois)

Similar findings were observed by Kuťáková & Janštová (2015) in attendants of biological olympiad summer camp. In consequence of this change of idea about how science is done in real, some participants decided to change their future career for something that will better meet their needs.

The job is very… very repetitive. I can't imagine myself doing it, because… it wouldn't fulfilled me. I prefer to… communicate with people and… meet new people and solve their problems. Therefore I think the medicine will be better for me. (Pankrác)

CONCLUSION

We interviewed eight upper secondary school students, who participated in a science project beyond their school education. We were interested in their attitudes towards scientific subjects, motivation which led them to participate in the project and the impact the project had on their image of science and scientists as well as on their future study and career choice.

All participants found their experience beneficial and evaluated the project positively. Motives to join the project were both internal and external. External one was usually the need to write a final thesis. The desire of field self-development was the one most ocurred internal one. Some students were motivated by their own science interests but also supported by their teachers. On the other hand, participants who did evaluated their teachers or school science negatively, attended the project too and were maybe even more excited. In general, the project met students' expectations, but for many of them, the image of science and the job of a scientist was modified by this practical experience. The idea of a „crazy“ scientist making experiments turned into an image of a person sitting by the computer and doing a lot of monotonous work. Based on the experience, some students assured themselves about their future study and career in scientific area, other participants, on contrary, changed their choice. Project have been proved to be benefitial to students which is in accordance with other studies (Lindner, 2014; Rusek & Lindner, 2017).

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Contact address

Mgr. Anna Fabryová; RNDr. Vanda Janštová, Ph.D.

Department of Education and Didactics of Biology
Faculty of Science
Charles University
Viničná 7
128 43 Praha 2
e-mail: vanda.janstova@natur.cuni.cz, anna.fabryova@natur.cuni.cz

PROJECT-BASED EDUCATION FROM PRIMARY TEACHERS' POINT OF VIEW

CHYTRÝ Vlastimil, KROUFEK Roman, NOVÁKOVÁ Alena

Abstract

This article deals with the perception of project-based education in primary school (years 1-5) classes in the Czech Republic. Attitudes towards a specific method and knowledge of applicability are analysed. The presented research tool manifests acceptable level of reliability α=.76. Age, sex, time period spent as an educator or time period in current school were chosen as determining variables. One of the most interesting results is correlation of attitudes and knowledge (r=55), which points to the fact, that knowledge of a specific method in terms of its suitable use is the determining factor in cases, in which educator has to make decisions, whether and when to use a specific method or not.

Key words

Attitudes, project-based learning, project based, primary school

INTRODUCTION

Project-based learning (PBL) originates from the idea of intertwining projects and lessons (Thomas, 2000). Thanks to the inclusion of project work into lessons[1] PBL originates from the idea of intertwining projects and lessons (Thomas, 2000). Thanks to the inclusion of project work into lessons this specific education process then can be described as an adaptation to specific experience[2] (Glasersfeld, 1995). Based on such real-life experience students are then able to better focus on inner educational process, which leads towards gaining more self-esteem and sense of responsibility (Villeneuve, 2000). „According to Krajčík, Blumenfeld, Marx and Soloway (1994) and Thomas (2000) the effective environment for PBL consists of five elements: (a) an authentic and engaging driving question, (b) student generated artefacts, (c) student collaborated research, (d) an audience of community, and (e) the use of technology-

[1] The inclusion of project based learning depends mainly on the teaching style of a particular teacher (e.g. Bendl, 2004, p. 50).

[2] Project based method of teaching is an interdisciplinary method which analyses problems in real life in natural environment and students are encouraged to create content based on their own decisions (Erdem, 2002; Schneider et al., 2002). Říčan (2012) focuses on the problem analysis in terms of PBL as a problem solving method.

based cognitive and communication tools" (Cervantes, Hemmer & Kouzekanani, 2015, p. 4). Many articles concerning project working class are based on the descriptions of lesson realisation, but there is a significant lack of research in the area of practical impact of such methods in life (Helle et al., 2006; Rusek, 2017). This particular article describes a research tool used for teacher attitude and knowledge analysis towards project based education. Elementary factors are mentioned below, and the main ideas are shifting towards the direction of the age of respondents and the length of their pedagogical career.

Theoretical background and outcomes of the analysis

There are a few discrepancies in terminology, which were previously pointed out by Kubátová (2014), who states that project based education is regarded as an education method (Vrána, 1934) or as an organisational of education (Skalková, 1995; Zilcher, 2013). Sometimes activities involved in integrated curriculum is mixed up with project based education (Šindelková, Málková & Plucková, 2015), even though they do not fulfil the elementary criteria of PBL (Rusek & Dlabola, 2013) and their project-like nature is missing (Rusek& Becker, 2012). Another concept can be found in the work of Harris & Katz (2001), Liu & Hsiao (2002), Moursund (2001) and others. For this reason, it is necessary to define key elements such as Barron & Darling-Hammond (2008) did.

To realise a project, one needs more active engagement of students and increased interest in the subjects thanks to a collaboration process during learning. PBL is then regarded as one of the most frequently used activation methods for student interaction (Hye-Jung, Cheolil, 2012). Team work through project work has a positive impact on critical thinking, creative thinking, and sense of responsibility and communication skills (Moursund, 2003). Apart from that the ability to work in a team is also improving, as well as problem solving skills and speaking skills (Samacá, Ramirez, & Vásquez, 2013). Project based learning can be seen as highly universal in relation to individual learning styles, but that does not mean it is fitting for all students. One of the negative elements of PBL is the fact that in some cases students without previous experience in project work and thus estimated their social role within a particular group (Lovasová, Mainz, 2012). PBL provides students with the opportunity to work autonomously over periods of time and produce realistic products that may include presentations to strategic audiences who have interest in the solutions (Thomas, 2000). Students in the PBL classrooms, which focus on authentic performance, collaboration, and students' choice of the learning activity, exhibit a higher degree of motivation than do non PBL students (Blumenfeld et al., 1991). The activities of the PBL are designed to promote a deep level of understanding of the content that is meaningful to the learner and high in collaboration (McGrath, 2004).

METHODOLOGY

Research data description

The study included 87 respondents all of which are university students of 5-year distance study program from the University of Jan Evangelista Purkyně in Ústí nad Labem (Primary School Teacher Education). Due to the low number of male respondents (n=10) the gender factor was not taken into consideration for further analysis. The data collection was done via 19-item questionnaire, in which the first 17 items focus on the knowledge of project work and the last two attitudes towards it. The testing tool was extended by additional items allowing teacher stratification based on theory presented by Rogers (2003, p. 282-285) who describes five groups of innovation adopters: innovators (comparable with PD-teachers), early adopters, early majority, late majority, laggards (comparable with TI-teachers). However vast majority of respondents (86 %) fit the laggard category and thus the differentiation according to this stratification, for example, as in Rusek, M., Stárková, D., Chytrý, V., & Bílek, M. (2017), was not possible.

Data processing method

Items 1-17 focus on the knowledge of PBL, in which items 1, 7, 12, 15, 17 had to be reorganised because of their antagonistic formulations. In order to assure the reliability of the scales and subscales used in this study, standard pedagogical research methods are appropriate for this particular theme. Due to the fact that respondents answered –level Likert scale test[3] (Likert, 1932; Chytrý, Kroufek, 2017) the Cronbach α coefficient was then calculated (Cronbach, 1951; McGartland Rubio, 2005) to assure internal consistency (validity) of the tool and can range between interval values 1 and 0, where the generally accepted values of the coefficient are between 0,7 a 0,95 (Tavakol, Dennick, 2011). The testing tool reached α=.76 and it is therefore regarded as a satisfactory result for a testing tool. The gained items and data were then summed and respondents varied on the scale between numbers 39-72. The results processed reaction were exported to Microsoft Excel 2010. Then the Statistica software (StatSoft Inc, 2016) was

[3] 5 – agree, 4 – rather agree, 3 – neutral opinion, 2 – rather disagree, 1 – disagree, N – do not know

used for data processing. The Shapiro-Wilks test confirmed that the data did not represent normal distribution.

The Shapiro-Wilks test confirmed that the data did not represent normal distribution. The determining variables were selected to be: i) age, ii) time period working in education (A: up to 3 years, B: 4-10 years, C: 11-20 years, D:21-30 years, E:31 – 40 years) all of which are described in table 1., iii) time period of last employment, iv) education level (middle school training of non-pedagogical origin, middle school of pedagogical focus, College/University degree of nonpedagogical origin, College/University degree of pedagogical origin).

Only factors no. ii and iv were grouped prior to the testing itself.

RESULTS

Interesting finding is that there are only small differences in mean and median values which suggest that a specific trend is occurring in terms of better knowledge of the subject according to the time spent in education profession (as shown in Fig. 1). The bales include traditional statistical markers such as: $\bar{x}$ – mean, $\tilde{x}$ – median, $\hat{x}$ – modus, and SD – standard deviation, max – maximum, min – minimum.

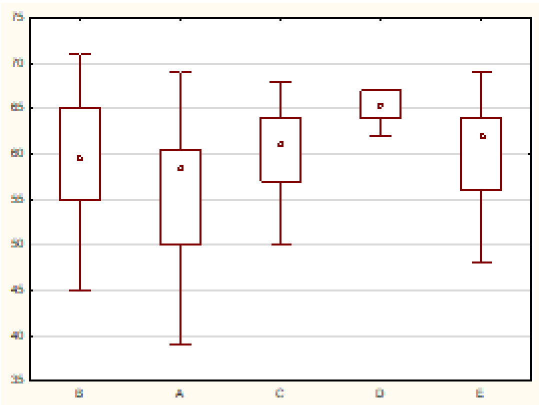

Fig. 1 Knowledge in relation to time in education, source: the author, 2017.

Table 1 Difference of respondents' answers based on time spent in professional teaching practice, source: the author, 2017.

	A	B	C	D	E		A	B	C	D	E
$\bar{x}$	55.95	59.64	60.08	66.00	59.80	SD	8.41	6.87	5.75	3.41	8.07
$\tilde{x}$	58.50	59.50	61.00	65.50	62.00	max	69.00	71.00	68.00	72.00	69.00
$\hat{x}$	60.00	54.00	61.00	------	------	min	39.00	45.00	50.00	62.00	48.00

The relation between the knowledge of the particular method of project based education and time spent in education was analysed based on Kruskal-Wallis test H (4, N=87) =9.47, p=.0504, where the p-level value suggests that there may be differences between data sets, as shown in picture 1 and table 1. It seems that not only time spent in education as a teacher, but also age (r=.26 - significant) can be determined according to the knowledge of project based learning and teaching. Respondents were then divided according to their performance into several categories: i) low (<31), ii) medium (31-50), iii) good (51-60), iv) excellent (>60). Based on the Kruskal-Wallis test H (3, N=87) =7.73 p=.0361 some differences were visible between age groups, as seen in table 2. Post-hoc analysis then showed that the only significant differences are between the groups of low and excellent performance. It seems that the youngest respondents had the worst performance and vice versa (as seen in Fig. 2.)

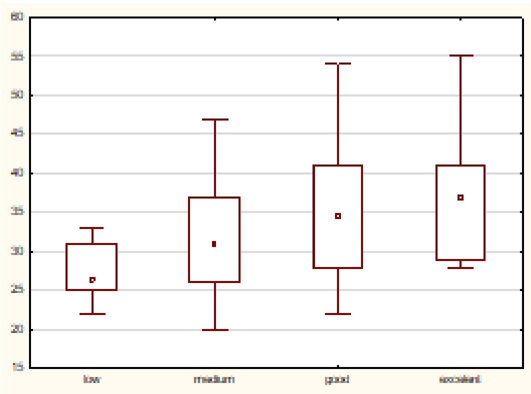

Fig. 2 Knowledge in relation to age, source: author, 2017.

Table 2 Division of respondents according to their knowledge, source: author, 2017.

Classification	Abs. / rel. frequency	$\bar{x}$	$\tilde{x}$	SD
Low	10 (11,63 %)	29,80	26,50	9,48
Medium	29 (33,72 %)	32,04	31,00	7,50
Good	25 (29,07 %)	34,68	34,50	8,57
Excellent	22 (25,58 %)	37,11	37,00	7,95

Similarly, attitudes towards the project work in class were analysed by the test in items 18 and 19 (see Table 3 and Figure 3). Respondents varied on the scale between values 2-10. Here again the correlation of age and attitude appeared (r=.27 – significant) and respondents then had to be divided into three categories: i) low attitude (<6), ii) neutral attitude (7-8), iii) good attitude (>8). In this case Kruskal-Wallis test H (2, N=87) =3.96 p=.106) did not show any statistically significant difference, however based on the graph below we may examine some pervasive tendencies.

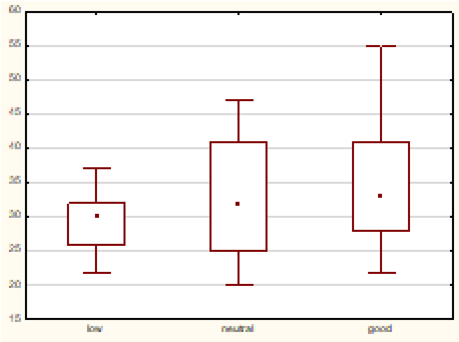

Fig. 3 Attitude division of respondents, source: the author, 2017.

Table 3 Attitude division of respondents, source: the author, 2017.

Classification	Abs. / rel. frequency	x	med	SD
Low	14 (16,28 %)	29,62	30,00	4,89
Medium	26 (30,23 %)	33,04	32,00	8,03
Good	46 (53,49 %)	35,51	33,00	9,13

Furthermore, Table 4 includes an overview of the inductive analysis showing individual observed and analysed variables.

Table 4 Overview of the observed correlations, source: the author, 2017.

Variables	Effect verification - knowledge	Effect verification - attitudes
Ages	r =.26 (significant)	r =.23 (significant)
Time period spent in professional	r =.27 (significant)	r =.30 (significant)
Time spent as a teacher in last	r =.08 (**insignificant**)	r =.19 (**insignificant**)
Education	p=.41	p=.16

The table shows that it is the knowledge of the method in terms of its suitable use in class to be determining factor in cases, in which the teacher decides, whether to use the method or not. The correlation of attitudes and knowledge was moderately strong (r=.55) and the effect size was statistically significant on the 5 percent base threshold.

CONCLUSION

It is surprising that the main determinant variable affecting respondents' knowledge of the project-based learning is the age. Our study suggests that the older the respondent, the better overview of the method. One of the main reasons for such state is probably higher frequency of course and seminar attendance which are related to project work education which are attended mainly by older teachers. Another reason may be higher confidence in own skills during pedagogical work, where more experienced educators are not afraid to experiment more and use alternative approach towards learning and teaching, including methods which were examined in our study.

The highest reached education has been proven to be irrelevant not only in terms of knowledge of a particular method, but also in terms of attitudes as well. This is very interesting, considering respondents included graduates from pedagogical faculties, technical faculties and many other. Some respondents had reached only high school degree and were currently in the process of studying a university program for teachers to gain academic title. But not even this fact discriminated them in any way and these teachers did not gained any statistically significantly worse results than their higher educated colleagues.

„In order to prepare the learners for the real-world, PBL calls for teachers and administrators to redesign instruction and assessments by giving students real-world problems to solve" (Cervantes et al., 2015, p. 15). Our study is in agreement with findings presented by Krajcik, Marx and Soloway (2002), stating, that educators should be encouraged to use inquiry-based approaches such as PBS to implement reform in their schools. PBL as an applied method in everyday class is simply important just by default need for motivation increase (Doppelt, 2003).

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Contact address

Mgr. Vlastimil Chytrý, Ph.D., PhDr. Roman Kroufek, Ph.D., Mgr. Alena Nováková

Katedra preprimárního a primárního vzdělávání
Pedagogická fakulta,
Univerzita Jana Evangelisty Purkyně v Ústí nad Labem
Hoření 13
400 96 Ústí and Labem
e-mail: vlchytry@gmail.com, roman.kroufek@ujep.cz, alena.novakova.ph@gmail.com

STUDENTS' ABILITY TO APPLY MATHEMATICAL SKILLS IN CHEMICAL TASKS

IVAN Matúš, ŠULCOVÁ Renata, TEPLÁ Milada

Abstract

A complex and interdisciplinary approach in solving problems is a prerequisite for the development of society. In order to achieve this, it is necessary to develop the generally applicable knowledge and skills of students since basic education. Science education and mathematics provide possibilities for development of these competences. In chemistry, many phenomena and processes cannot be explained simply to the students without the involvement of mathematical apparatus. Similarly, in mathematics, it is difficult to explain the importance of theoretical approaches without applying experience from common practice, for example, in explaining the structure of chemical substances or chemical calculations. Inquiry-based science education is suitable teaching method for solving the problems mentioned above.

Key words

Chemistry, graphical representation, inquiry-oriented learning, knowledge construction, models in science

INTRODUCTION

The necessity of using mathematical skills in other areas of science resonates in many professional articles and monographies of renounced specialists in the field of science and education.

According to publication of M. Bílek (chemistry and science educator) publication, visual and graphic literacy, visualization and chemical modelling, measurement, experiments and their statistical evaluation are the main connections of mathematics and natural sciences (Bílek, 2007). A similar evidence can be found in M. Nodzyńska (chemistry and science educator): "graphical information are nowadays usual part of transmission of facts, we need to consider the ability of people to comprehend these information" (Nodzyńska, 2012).These opinions support the interdisciplinary connections of mathematics and chemistry – spatial imagination using planimetry and stereometry.

According to V. Lamanauskas (science educator) "science and mathematics are taught at school referring to formulas, theorems, blindly following the textbooks, there is a lack of problem situations and practical examples. It is necessary to show the students practical use of mathematics and science; this requires the cooperation among teachers of these subjects" (Lamanauskas, 2014). The practical use of these skills is best shown in real life problem solving.

Also some of the mathematics educators provided evidence on the matter. J. Bečvář (mathematics educator) found out that "people believe that they don't need the mathematics for their life, although there are many curricular documents accenting the importance of natural sciences and mathematics" (Bečvář, 2012). Likewise, A. Šarounová (geometry and mathematics education) wrote about the perception of objects: "at first, we receive the information about an object in two dimensions. Only our experience 'forces us to see' the spatial bodies in 3D, which is not obvious. We receive the information via sight, hearing and movement thus the remembering is more permanent" (Šarounová, 2012). Both of these authors confirm the importance of specific examples in chemistry for construction of theoretical mathematical skills.

The evidence from above provide rudiments for our research. Therefore we have defined goals for our research: to identify the areas of connection and intersection between chemistry and mathematics and to design, create and verify educational materials that will help the students increase their skills in interdisciplinary problem-solving.

BACKGROUND OF RESEARCH

Many phenomena in chemistry can only be explained using the mathematical apparatus. It is also a great problem for mathematics to show the meaning and importance of theoretical principles. The mathematical principles can be explained better through applying in problem solving. Our research task was to develop materials to support students' construction of concepts in chemistry using mathematics.

First step was to analyse the content of education in chemistry and mathematics to pinpoint the areas of their connection (The Framework Educational Programmes and the School Educational Programmes were analysed). To identify these areas we had to perform three surveys. The first was content analysis of state and school curricular documents of Czech and Slovak republic, the second were 13 interviews with secondary school teachers of chemistry and mathematics. The third source was item analysis of extensive testing of skills and knowledge in chemistry.

Analysis of curricular documents

The state curricular documents of the Czech Republic "Framework Educational Programmes" are built up in an interdisciplinary way (complex and interdisciplinary approach to problem solving, systematic character of nature). Content analysis of the aims of the curricular documents has proven that the Czech school system provides complex interdisciplinary education and skills for problem solving. The mathematical skills and conceptions of students are often naturally engaged in the area of chemistry problem solving. In turn, the objectives of mathematics can be fulfilled by problem solving in chemistry education (chemical calculations, functional dependence, spatial structures and their geometry and logical and analytical thinking). The School educational programmes of 24 grammar schools have also been analysed in stratified research survey to verify the documentation of interdisciplinary education principles connecting chemistry and mathematics. All of the school educational programmes included educational goals that connected the examined fields. In 67 % of cases, the goals set by the educational programmes in content of chemistry have been focused on algebraic calculations, in 27 % of goals in analysed documents include spatial imagination and geometry in chemistry.

Interviews with secondary school teachers

Last year, twelve interviews with secondary school teachers have been conducted. The interviews were performed once with every teacher during the school year 2016/2017. The questions were aimed at the specific information about the areas of connection between mathematics and chemistry that cause the most difficulties among the students, the ability of students to use the mathematical principles in chemistry and the materials that are available to the teachers including interdisciplinary tasks. These interviews helped us to refine the students' difficulties in comprehension of conceptions. The questions offered selected problematic areas and the possibility of free answers. The analysis of the interviews more precisely specified the areas we have searched for. Most of the teachers (11 out of 12) agreed that the most problematic parts for students are chemical calculations, stereometry of chemical structures and functional dependence of quantities.

Item analysis of extensive testing

Over the last 5 years, we have researched the thought processes and practices of secondary school students in dealing with chemical tasks that require the use of various mathematical operations. The detailed item analysis of 1079 students' test solutions collected by T. Cífková during extensive testing in 2013-2015 (Cífková, 2015) and the following testing during 2015 and 2016 (162 more tests) provided us with information about specific items in content of chemistry education that have caused students the most difficulties. However, some of these difficulties can be caused by the lack of mathematical skills but also the lack of knowledge of chemical principles.

Results arising from previous analysis

Bringing together the results of the analysis of curricular documents, interviews with secondary school teachers and the extensive testing (Cífková, 2015) that was subsequently analysed (the analysis inquired about the successfulness of students in solving tasks that require the use of mathematical skills) we have selected the most problematic items (these items were chosen because each of these tasks was less successful than the success rate of the whole test) that are summarized in the Table 1.

Table 1. Mathematical skills and their applications in chemistry, source: authors

Mathematical skill	Area of application in chemistry
Application of algebra and calculations	▪ direct and indirect proportion in general chemistry calculations, solution compositions ▪ expressing an unknown from a formula
Spatial imagination using planimetry and stereometry	▪ arrangement of atoms in molecules and crystals ▪ modelling and construction of structural particles ▪ creation of models and formulae ▪ graphical expression of structural formulae
Analytical logical thinking and data interpretation and evaluation	▪ graphical evaluation of an experiment ▪ application of logical principles for explanation of structure and reactivity of chemical compounds ▪ practical application of physical-chemistry laws for thermochemistry and chemical kinetics
Functional analysis	▪ spatial shapes of orbitals, explaining the creation of chemical bonds ▪ functional dependence of measured values of physical-chemistry quantities

To verify our assumptions about the use of mathematical skills in problem-solving in chemistry we conducted follow-up testing using a new test. The tasks in this test were created based on the most problematic items that have been revealed in the previous test (via the detailed item analysis mentioned earlier) Using the new test with interdisciplinary tasks - in accordance with the principles of creating the educational tasks (e. g. language form, stimulative force, substantive content, motivational charge of the task – Čtrnáctová, 2009), we have been verifying the secondary school students' and also university students' abilities to apply mathematical skills and logical considerations to solving chemical problems.

The results of the pilot testing can be summarized in a few conclusions. The success rate of 142 secondary school students is higher than the success rate of 51 university students (see Table 2 – results of analysis of test items and comparison between of secondary school and university students). The main reason for this strange outcome could be the factor of forgetting, but also insufficient interdisciplinary connection between mathematics and science subjects and logical applications of knowledge and skills in science into practical problems. The interest and motivation of the students in the subject of chemistry could also be a next reason for the difference between the secondary school students and university students (the results of the students that were about to graduate in chemistry were better than the others). While solving the tasks demanding comprehensive reading, students made mistakes out of inattention (16 % of secondary school students and 39 % of university students).

Table 2. Comparison of success rates between secondary school and university students, source: authors

	Area A	Area B	Area C	Area D	Area E		
Secondary school	56 %	48 %	26 %	78 % GC	84 % BC	77 % (models)	90 % (allotropes)
University students	22 %	17 %	9 %	61 % GC	78 % BC	70 % (models)	34 % (allotropes)

Explanatory notes:

Area A - Comprehensive reading; Area B - Logical reasoning using mathematical principle of a concept in physical chemistry; Area C - Data analysis and evaluation; Area D - Interpretation of tabulated data; Area E - Structure of compounds and spatial imagination; GC = general chemistry, BC = biochemistry

To demonstrate typical examples of interdisciplinary interventions there are two examples in the following text that could help the students with test tasks of Areas B and C (first example) or the tasks of Areas A and E (second example).

PROPOSED SOLUTIONS

The research has concluded in two main solutions that could help the students with the difficulties in using mathematics in chemistry. The first solution is to rearrange the educational content of subjects in curricular documents. This systematic change is very difficult to enforce. Students could better apply their skills across different subjects if the school educational programmes harmonized educational contents of chemistry and mathematics (e.g. solving equations in mathematics creates the basis for chemical calculations, and vice versa the chemical calculations can serve as the practice for theoretical mathematical knowledge).

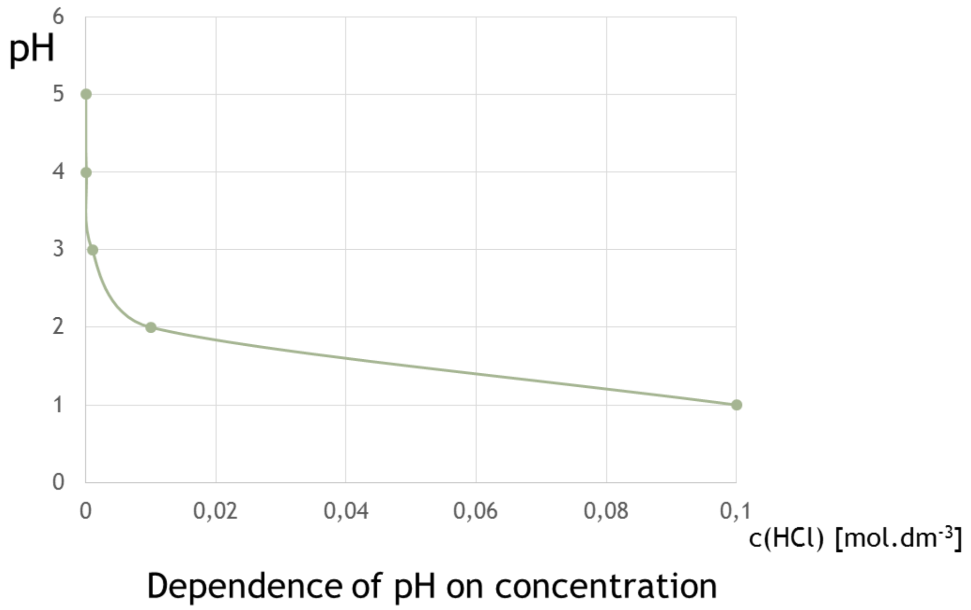
The second solution of the problems mentioned above is development of educational tasks for the usage in the exposure phase of teaching. The described tasks should contribute to the gain of the necessary skills and to their effective application by students.

EDUCATIONAL MATERIALS

Development, creation and verification of accessible interdisciplinary educational materials accenting connection of mathematics and chemistry and science in general is one of the main products of our research. The materials were created to fulfil requirements for guided and possibly open inquiry-based science education (IBSE). Then the students gradually learn basic principles of project management and IBSE and they can benefit from the skills gained during these activities in interdisciplinary project-based education (PBE). Inquiry-oriented education belongs to the methods that make the PBE an extensive and effective approach to engage science to other disciplines (Rusek, 2017). Below, we shall introduce two tasks from the developed materials. The first task is focused on functional dependence of quantities and the second draft is focused on the theory of sets and spatial imagination in mathematics and chirality and symmetry in chemistry (as is seen in Table 1).

How to derive the dependence of pH on concentration of a solution

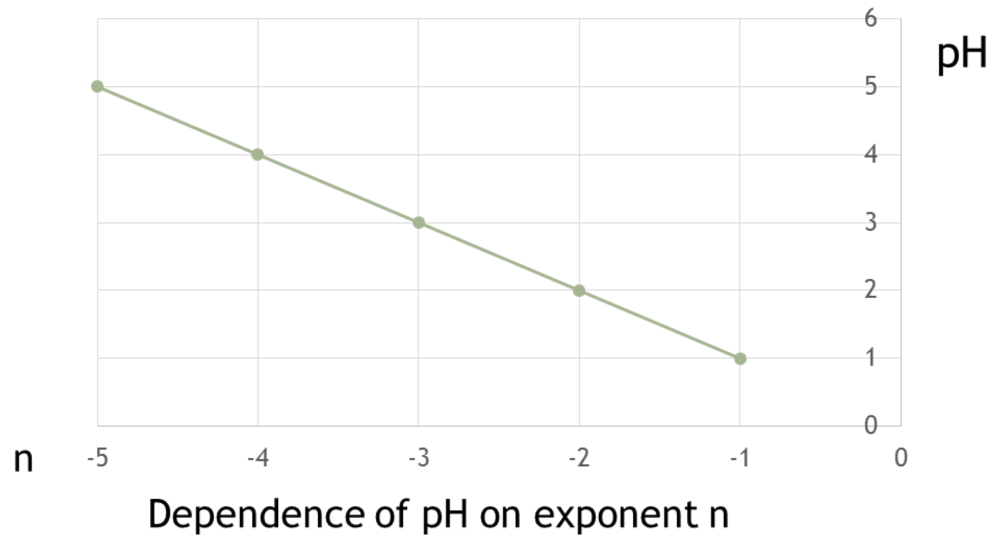
Students are asked to figure out the dependence of pH on the concentration of an acid. Their first task is to plot a graph of dependence of pH on concentration. They measure the values of pH of solutions of an acid with various concentrations using pH meter or pH indicator. Then they plot the graph based on the measurement (see Graph 1)



Graph 1. Dependence of pH on concentration c

The graph of the dependence is a mathematical curve – logarithmic function. Can we change some of the values so that the plot will be a simpler function? If we dilute solution (c = 0,1 mol.dm^{-3}) in 1:10 proportion in every step ($c_n = 10^n$) we could either use the exponents (n) or the serial number of the dilution instead of the 'real' values of concentration.

The new plot will be a line represented by equation $y = -x$ (or $y = x$); see Graph 2.



Graph 2. Graphical representation of dependence of pH on exponent n

Students inquire about the mathematical meaning of the operation – replace a number 10^n with the exponent n. The operation is represented by logarithmic function. The students naturally understand why there is a logarithmic function in the definition of pH as is shown in their conclusions ("pH is dependent on concentration", "pH is negative exponent of concentration", "pH is logarithm of concentration of acid").

The concept of symmetry and chirality

Students are presented with formulae and chemical models of 10 - 15 compounds. They should inquire about the categorisations of proposed formulae. The compounds can be divided into sets of chiral and achiral, symmetric and asymmetric which are disjoint (they have an empty intersection) interpreting the definition. Subsequently the students find out there are some compounds that are asymmetric and chiral (e. g. valine or glucose), symmetric and achiral (e. g. pyrrole or acetone). Moreover, a few of the compounds are symmetric and chiral (e. g. helicene or allene) but asymmetric achiral compounds do not exist.

Students manifested this knowledge graphically the customized Venn's diagram themselves (see Figure 1).

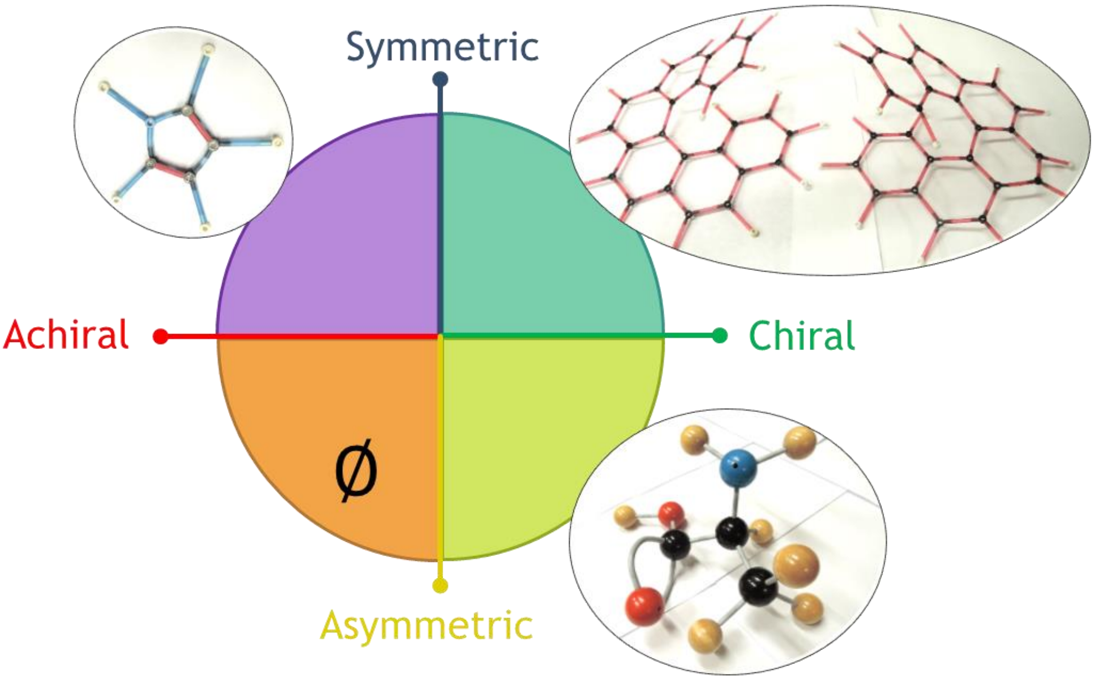


Figure 1. Graphical representation of conceptions: “symmetric” and “chiral”

Students often experience difficulties understanding the meaning of the concepts symmetry and chirality. To better comprehend the explanation of these phenomena they can find help in the principles of the mathematical logic and the set theory.

The principles of symmetry and chirality are often used in other areas of life besides chemistry like architecture, biological structures, aesthetics and art. Students search for their own examples.

CONCLUSIONS

The literature research provided us with the basic idea of our research – the construction of students’ conceptions in chemistry using the mathematical apparatus. The analysis of curricular documents and extensive testing in chemistry had specified the linking areas of chemistry and mathematics. The specific problematic conceptions and typical errors in solutions were determined by follow–up testing and interviews.

The sections of research mentioned above concluded in recommendations. The most feasible proposition is the creation of educational materials. IBSE activities, educational tasks, worksheets and laboratory inquiries accent and support the interdisciplinary approach to education and simplify the process of preparation of lessons by the teachers.

Presented educational materials highlight the usefulness of mathematics in problem-solving in chemistry (e.g. set theory used in chirality and symmetry). Likewise the comprehension of mathematical theoretical conceptions can be facilitated by the problem solving in chemistry (e.g. meaning of logarithmic function in definition of pH).

The interdisciplinary approach to education in schools is a necessary condition for further complex problem-solving of everyday issues in professional life.

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Contact address

Mgr. Matúš Ivan, RNDr. Renata Šulcová, Ph.D., RNDr. Milada Teplá, Ph.D.

Department of Teaching and Didactics of Chemistry,
Faculty of Science,
Charles University
Albertov 6
128 43 Prague 2
e-mail: ivanma@natur.cuni.cz, renata.sulcova@natur.cuni.cz, milada.tepla@natur.cuni.cz

CHEMICAL ELEMENTS IN THE PUPILS' VIEW

SOCHOROVÁ Klára, CHROUSTOVÁ Kateřina, MACHKOVÁ Veronika

Abstract

The project “Our Periodic Table of Elements” was initiated by the eighth-grade primary school pupils in April 2017 and it took 6 months. They decided to decorate the Chemistry classroom with a large periodic table composed of handmade individual elements’ pictures. The created pictures were subsequently subjected to content analysis. The aim of it was to determine the relationship between the element and its visual expression from the pupils´ point of view. These relationships were generalized into eight basic categories. We also focused on the sources of information used as a basis of the visual expression of elements and its comparison with the content in Chemistry textbooks.

Key words

Chemistry, Project based Learning, Student Choices, Primary school, Graphical Representations, Content Analysis

INTRODUCTION

The project method is considered to be an alternative to traditional frontal teaching and it is based on principles of constructivism, egocentrism, and cooperative learning (Rusek & Dlabola, 2013). In the school environment the project is set in several phases: Initiation, Planning, Realisation, Results/Evaluation (Bílek, Machková, & Chroustová, 2016). Each of the phases has its significance and specificity. During the project execution the intrinsic motivation of the pupils plays an important role; it affects not only successful closure of the project but also a quality of output including development of pupil’s personality. Abundance of intrinsic motivation to execute the project is closely connected to those who proposes the project. The general ideal is that when the pupils themselves initiate the project, it makes them interested in finishing the project. Open and friendly environment in the school is also beneficial (Bílek & Machková, 2015). In the forthcoming text we are going to deal with realization and analysis of pupils’ spontaneous project called “Our Periodic Table of Elements”.

Chemical elements, their properties and periodic trends create the foundation stone of Chemistry education (Franco-Mariscal, Oliva-Martínez, & Gil, 2016). Periodic table published in the textbook *The Principles of Chemistry* can be perceived as a result of a big project of D. I. Mendeleev in 19th century whose goal was to arrange the elements into a system that would help students remember their properties better (Weinstein, 2016). Pupils often come across the periodic table sooner than they learn about its relevance and periodic trends, for example in Chemistry textbook or in the form of board in Chemistry classroom (Hanzalová, Chroustová, 2014). Regarding the importance of this table for Chemistry and Chemistry education it is necessary to convey the knowledge of periodic trends including placement of elements in the periodic table, which can be a difficult task for pupils of elementary schools.

In an attempt to make this curriculum more attractive for pupils and help them understand it better many activities and variations of the periodic table have been created, for example an illustrated periodic table, photographic periodic tables, interactive periodic table with videos of experiments, but also popularizing or educational videos (i.e. *The NEW Periodic Table Song*). We can also come across different activities in Chemistry lessons, being it games or active learning methods (i.e. Franco-Mariscal, Oliva-Martínez, Blanco-López, & España-Ramos, 2016; Larson, Long, & Briggs, 2012; N from the Learning Ark, 2016, October 31; Woelk, 2015). More inspiration can be found on websites where teachers share their experiences from teaching. We often come across educational projects where pupils create their own periodic table, i.e. *Periodic Table Project* (Miklius, 2012), *Class Project: Let's Build a Periodic Table!* (CrazyScienceLady, [2015]).

PUPILS´ PROJECT CHARACTERISTICS

At the beginning of the project “Our Periodic Table of Elements” was a wish of some pupils in the eighth grade to make an unsightly wall in the classroom nicer. The winner among the suggestions for topical decoration of the classroom was an idea to create cards for individual Chemical elements which will be hung on the wall in the classical arrangement of the periodical table. The initiative spread among pupils from other classes that visited the Chemistry classroom. Finally, pupils’ representatives from all eighth and ninth grades of FZŠ Palachova, Brandýs nad Labem, participated in creating the periodic table. Detailed characteristic of this project come out of typology of projects according to J. Kratochvílová (2006, s. 48) can be found in Table 1 below.

Table 1: Characteristics of the project “Our Periodic Table of Elements”

Viewpoint of typology of projects according to Kratochvílová	Type of project	Additional information
Proposer of the project	pupils/spontaneous	initiative came from the pupils
Purpose of the project	constructive	the project focused on creative work of the pupils
Sources of information for the project	free	the pupils acquired information on their own and were not restricted by any rules
Length of the project	very long	the pupils created individual cards during 14 weeks – this project will still have follow up
Environment for the project	combination of school and home project	the pupils created individual cards at home, consultation and assembling of the periodic table (presentation of the product) took place at school
Number of participators on the project	collective	during the project there was interclass and inter-year cooperation of the pupils, three eighth year classes and three ninth year classes were participating in total
Method of organization of the project	one subject	individual steps were consulted only in Chemistry lessons

To achieve the united look, the pupils decided on the following basic points for creating individual cards: a) size of the card (21 x 21 cm)

b) presence of element symbol

c) colour differentiation of characteristic groups

d) graphical representation of anything, that will characterize given element.

The pupils could find inspiration for the visualization of the elements in Chemistry lessons, in textbooks, accessible literature and on the Internet. Anything that characterized the element in the view of the pupils could have been visually represented – its looks, its discoverer, or a language connection with the name of the element. Each individual graphical depiction was consulted with the pupils after they handed it in to avoid a wrong interpretation.

The pupils created cards illustrating 100 chemical elements in total during 14 weeks (minus summer holidays) of the realization process. The cards were compiled into a big table in the Chemistry classes of the elementary school in September 2017 and all involved groups had a chance to comment and evaluate the finished product. The finished table became practical requisite for Chemistry lessons and also incited interest of younger pupils who are planning another project.

The pupils were not bound by strict rules during the creation of the element cards; they could have used any association on how to visually create the element, therefore many different interpretations of individual elements appeared in the finished periodic table. Next, graphical representation of the elements underwent the content analysis to identify a connection between the element and the graphical representation.

CONTENT ANALYSIS OF PUPILS´ VIEW OF CHEMICAL ELEMENTS

Methodology

Content analysis can represent not only a research tool, procedure, technique, method but also a methodological approach or way, a conceptual framework and a theoretical perspective (Dvořáková, 2010). The subject of the content analysis is the content of the communication, which can be transmitted as a text or an image, which are subsequently examined with respect to several selected characters whose occurrence is captured (Dvořáková, 2010). In our conception this is a content analysis in a narrower conception according to Dvořáková (2010), so called a conceptual analysis that serves to quantify the presence of a particular character and serves to compare phenomena.

This is single-level analysis with individual concepts or more precisely coding categories derived directly and inductively from the data obtained (Elo & Kyngäs, 2008). In the case of inductive content analysis, open coding including notes and headings is used first, followed by creation of the categories and abstraction (Elo & Kyngäs, 2008).

Within the content analysis we have also focused on whether new periodic table includes new and useful information for the pupils. At first, we identified whether the information for individual graphic representations could be found in the lessons or in the textbook used in Chemistry lessons (Škoda & Doulík, 2006, 2007). We also compared the timeline with the date of making the card and the time of teaching the elements during the chemistry classes, i.e. whether they were discussed in more detail or not.

The size of the sample analyzed consisted of 100 cards with 123 shown phenomena.

RESULTS

On the basis of the open coding the graphical representation was divided into nine categories (see Table 2), where each percentile of an individual category is presented in the diagram in Figure 1. The basis is not a number of element cards but the sum of visual occurrences (N = 123, in some cards there was more occurrences).

Table 2: Characteristics of the categories

Category	**Illustrated phenomenon**
Use of the element	products for which the element or its compound is or was used; important element effect; a symbol for the area of use of the element
Language similarity	the similarity of the name or the symbol of the element with the name or abbreviation of a product; with the name of some place, city or state; with the name of an animal, plant, fairy-tale, mythological or game character etc.
Appearance of the element	a piece of a specific element
Properties of the element	in addition to the appearance of the element, it is possible to determine other of its properties; symbol of radioactivity
Presence of the element	where the element is find; where the element is mined
Historical figure	discoverer of the element; depicted personality after which the element was named
Inner structure of the element	atomic models of individual elements; crystal structure of individual elements
Compound of the element	the appearance of the compound of the element
Others	phenomena not belonging to another category, e.g. year

The most of graphical representations were focused on the use of the element (i.e. iridium – syringe), language similarity (i.e. francium – Eiffel tower, French flag) and appearance of the element (i.e. bismuth – a piece of bismuth). Fewer pupils chose to use properties of the element for graphical representation (i.e. sodium – cutting with knife), presence of the element (i.e. potassium – banana), inner structure of the element (i.e. bohrium – atomic model of bohrium), historical figure (i.e. radium – Marie Curie Skłodowska) or a compound of the element (i.e. boron – borax). The category Others included the year 2016 for nihonium – the year the name and the symbol were approved.

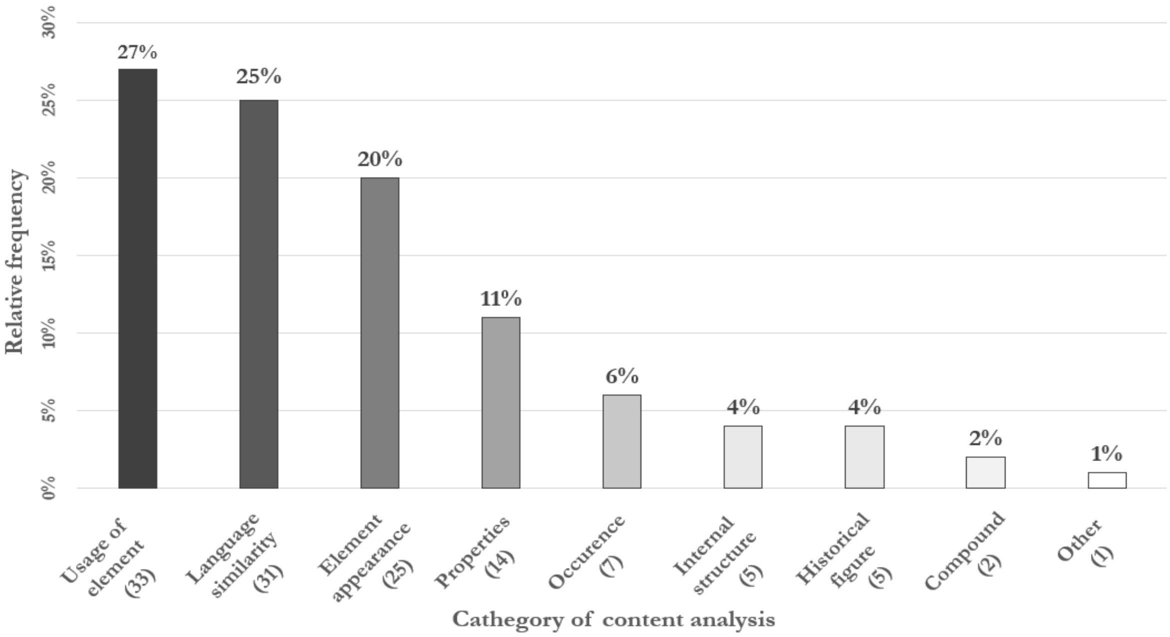

Figure 1 Graphical representation in the categories of content analysis

The analysis showed that 63% of graphic representations were not based on information that pupils could draw from Chemistry lessons therefore they had to use additional sources. The pupils could not have drawn even 79% of the representations from the textbook (Škoda & Doulík, 2006, 2007). Considering that a substantial part of new information was created by cards focusing on language similarity, which does not convey new important Chemistry information to the lesson; these cards were not included in the analysis. The results showed that compared to Chemistry lessons the cards included new useful information concerning about 37 elements, compared to the textbook (Škoda & Doulík, 2006, 2007) the information included even about 50 elements.

The comparison of time axis according to the date of making the card provided us with highly interesting information regarding the division of the elements according to whether they were discussed during the Chemistry lessons or not. As apparent from the diagram in Figure 2, pupils did not pick only elements that they knew from the Chemistry lessons, but they often focused on elements they did not know. The first card was surprisingly dedicated to krypton and its green radiance in ionized form. In the second week wolfram was submitted, which was depicted by an arrowhead and a ring. On the other hand, in the thirteenth week the cards about magnesium and oxygen were submitted.

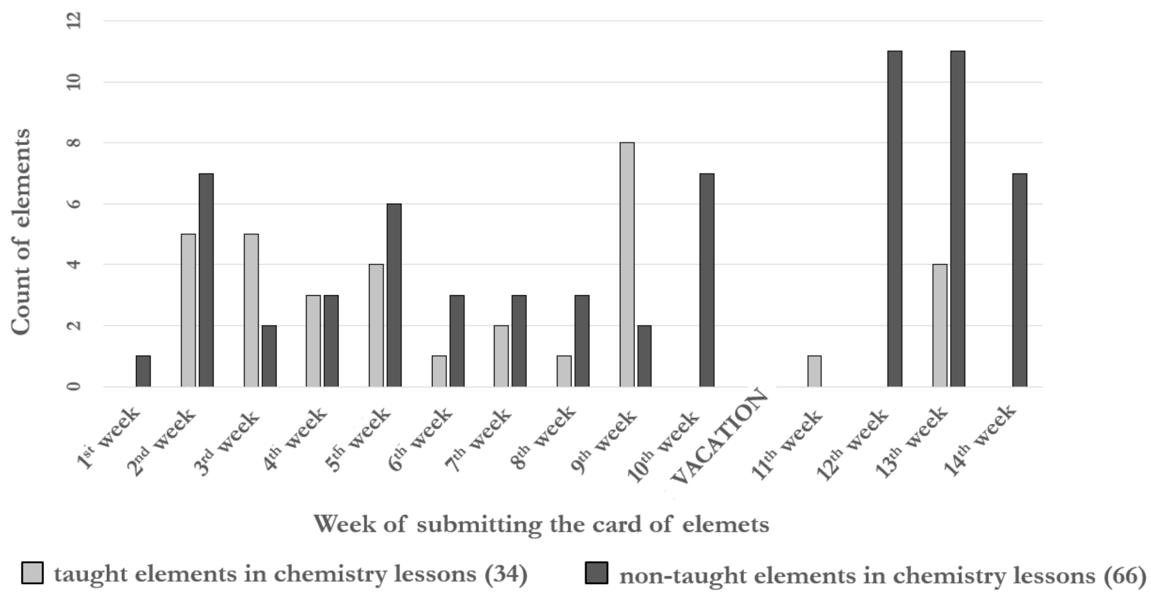

Figure 2 Number of submitted element cards in individual weeks of the project

CONCLUSION

This work described pupils' project that started spontaneously, and its goal was to make the environment in the Chemistry classroom nicer using a large periodic table that was created by hand-made cards with graphical depictions of Chemical elements. During the project the basic team of the pupils expanded and included younger pupils, which corresponds with theory of project teaching that emphasizes importance of pupils' initiative and open friendly environment in the school.

Product of the pupils' project was a graphical depiction of most of the chemical elements hung on the wall in the shape of the periodic table that underwent content analysis with a goal to identify a connection between an element and the depicted phenomenon. A usual connection between an element and its depiction was (1) a practical application of the element and (2) a language similarity between name of an element and depicted phenomenon. Both possibilities were covered approximately in one fourth of the cases. We perceive an option (1) from the concept acquiring a point of view as more important and beneficial; moreover, there is an apparent need of pupils to connect Chemical elements to the practical life. We perceive an option (2) as less beneficial since the only use is mnemonic and helps remembering the name of the element better and some of the depictions had only language similarity without any Chemical context.

The analysis has also revealed that preference of an element that pupils chose to adapt was not dependent on whether the element is generally known (i.e. oxygen, nitrogen, carbon) or if the pupils already learned about the element in Chemistry lessons. This can be explained by the fact that the pupils were drawn towards less known elements for the reasons of certain unknown territory which they were trying to explore, or that all the chemical elements are equal for the pupils that only started their Chemistry education therefore whether public experts see the elements as more or less known, had no influence on what element the pupils chose. While searching for information concerning graphical interpretation of Chemical elements, the pupils primary used different sources than information from the lessons and from the textbook; thanks to that in one third of the cases while creating the chemical element cards they used information that is not usually conveyed during Chemistry lessons or in the textbooks.

In the conclusion we can draw is that spontaneous interest of a few pupils to solve an aesthetic problem in the Chemistry classroom that was well handled and directed by the teacher led to a rise of interest among pupils from different classes, to the creation of functional lesson requisite and to the discovery of information about chemical elements that are not usually included in Chemistry lessons. The greatest contribution of the project is that it provided the pupils with enough opportunities to develop their key competencies, that is the learning competencies during the searching and usage of information, the social and personal competencies during the project cooperation and the development of positive working environment, the working competencies during creation of their own product, and finally the communication competencies and the problem-solving competencies during the defence of their element adaptation and critical evaluation of their own work and also work of their classmates.

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Contact address

Mgr. Klára Sochorová, RNDr. Kateřina Chroustová, Ph.D., RNDr. Veronika Machková, Ph.D.

Department of Chemistry
Faculty of Science
University of Hradec Kralove
Rokitanského 62
50003 Hradec Králové
Czech Republic
e-mail: klara.sochorova@uhk.cz, katerina.chroustova@uhk.cz, veronika.machkova@uhk.cz

INQUIRY EDUCATION IN BOTANY – A WAY TO COPE WITH PLANT BLINDNESS?

RYPLOVÁ Renata

Abstract

Humans ignorance of the plants in our surroundings, called as „plant blindness“ is a serious environmental problem of human society. As one of the reasons of plant blindness the low attractiveness of botany learning at school is considered. This contribution brings the results of the survey testing the impact of inquiry education on the attractiveness of botany education at Czech schools. The results indicate, that inquiry approach, especially in combination with outdoor education and supported by the use of modern technology can attract the students to botany.

Key words

Inquiry-oriented learning, environment, biology, outdoor education

INTRODUCTION

What is it plant blindness?

The phenomenon of "Plant blindness" was named already by Wandersee and Schussler (1999), but persist like important environmental problem of human society several decades until the recent time (Uno, 2009). Plant blindness characterizes the human's inability to see or notice plants around us and the ignorance of the role of plants in our environment. Considering the circumstances of global climate changes and the crucial environmental role of plants for the future of humans being, this seems to be alarming.

The reasons for the low interest of people in plants can be discovered already at the school level. As follows from the international research, plants are for the students less attractive than animals (Balas & Momsen, 2014, p.439), to learn botany is boring and difficult. (Prokop et al., 2007, p.37)

Plant blindness can lead to plant illiteracy (Uno, 2009, p.1753). Ignorance of the plants, especially of the plant physiological processes influencing significantly our environment, can lead to the wrong interference into vegetation or even incorrect landscape management causing serious problems for the people, as for instance increase of drought in recent time (Huryna & Pokorny, 2016)

Hence, it seems to be a challenge for the botany educators to attract the students to botany education.

Inquiry based science education (IBSE) is internationally known as didactic approach attracting the students to the study of the nature (European Commission, 2007).Therefore there are presumptions, that the use of inquiry approach in teaching botany could enhance the attractiveness of the plants for our young generation. From this reason we have conducted a survey testing the suitability of IBSE to enhance students' interest in plants and their role in human's environment. The goal of this survey was to find answers on two research questions: 1. Can IBSE enhance the attractiveness of plants for the students? 2. How to make inquiry based botany education more attractive for students?

METHODOLOGY

Inquiry units used in the survey

For the investigation of an impact of inquiry approach on students' attitudes to plants three different inquiry units related to the three different topics of plant physiology were used and applied at Czech basic and secondary schools:

1. „Why do spices smell? " Inquiry laboratory unit according to the rules of guided inquiry education, focussed on secondary plants products, applied at three Czech secondary schools, 2nd grade students.
2. „Interview with a tree" Inquiry unit focussed on environmental role of trees, supported by interactive white board and including hands on activities aimed to volatile organic compounds applied at three Czech basic schools, 7th grade student.
3. „Why is a shadow under a tree cooler than a shadow under an umbrella?" Inquiry outdoor unit focussed on plant water metabolism, using modern measuring devices during inquiry experiments, applied at three Czech secondary schools, 2nd grade students.

The duration of each unit was 90 minutes. The frame of all three inquiry units was the same:

1. Motivation followed by inquiry question
2. Constructing of the hypothesis under the guidance of the teacher
3. Experimental (hands-on) activity to prove the hypothesis
4. Formulating and presenting conclusions by students

5. Discussion on the results with the peers and teacher
6. Final overview made by teacher

Design of the didactic survey

During the research, a pre-test/post-test experimental design was used. Each inquiry unit was tested at three randomly chosen schools without any previous experience in inquiry education in the Czech Republic, in a total 426 respondents at the age of 13 – 16 years took a part in this survey. The students of each school were randomly divided into two groups. The students of focus group were taught by inquiry approach, students of control group were taught the same topic by regular teacher centred frontal approach. Both teaching units took 90 minutes. Each inquiry unit was taught by the same teacher at all three schools. All the students underwent a pre-test before the teaching and post-test 1 – 2 weeks after the absolved education.

To get the information about student attitudes to plants, a short questionnaire was used. The main part of the questionnaire consisting of three questions was the same in pre- as well as post-test:

1. Do you prefer plants or animals?

2. How attractive is for you to learn about plants? (Likert-type scale question, grade 1= boring, grade 5= amazing) (“Attractiveness of botany education”)

3. How much are, according to your opinion, the plants important for human environment? (Likert-type scale question, grade 1= unimportant, grade 5= very important) (“Importance of plants)

In the pre-test, additionally, a fourth question was asked to obtain information about students’ knowledge of plants environmental role:

4. Name exactly, how plants are useful for human environment: (open type question)

This question was not asked in a post-test, but instead of that, the students of focus group were asked to answer following two questions, to discover the attractiveness of applied education:

a) Do you find this lesson interesting for you?

b) What do you like best of all during this lesson? (Just one possible answer)

The obtained data were analysed by using STATISTICA 12 PC Package (StatSoft Inc.). The analysis of the Likert- type scale questions was done according to the recommendation of previous studies (Chytrý & Kroufek, 2017, Norman, 2010). For the comparison of the results Kruskal – Wallis ANOVA (Attractiveness of botany education and Importance of plants were considered as dependent variables, type of education (IBSE or teacher centred education) as grouping variables) and median test were used.

RESULTS AND DISCUSSION

According to the results of pre-tests, 88 % of the respondents prefer animals to plants. This finding is in agreement with some foreign studies (Balas & Momsen, 2014, Patrick & Tunnicliffe, 2011).

For the students of focus as well as control group, botany education was less attractive (Median = 2, Fig.1). The importance of plants for our environment in pre-test was considered as less to average important (Median = 2 and 3, Fig.2). No significant differences were discovered among the both tested groups in pre-.test for attractiveness as well as importance of plants according to the Kruskal – Wallis test, ($p = 0.05$). In post-test significant differences among the tested groups were discovered ($p < 0.01$).

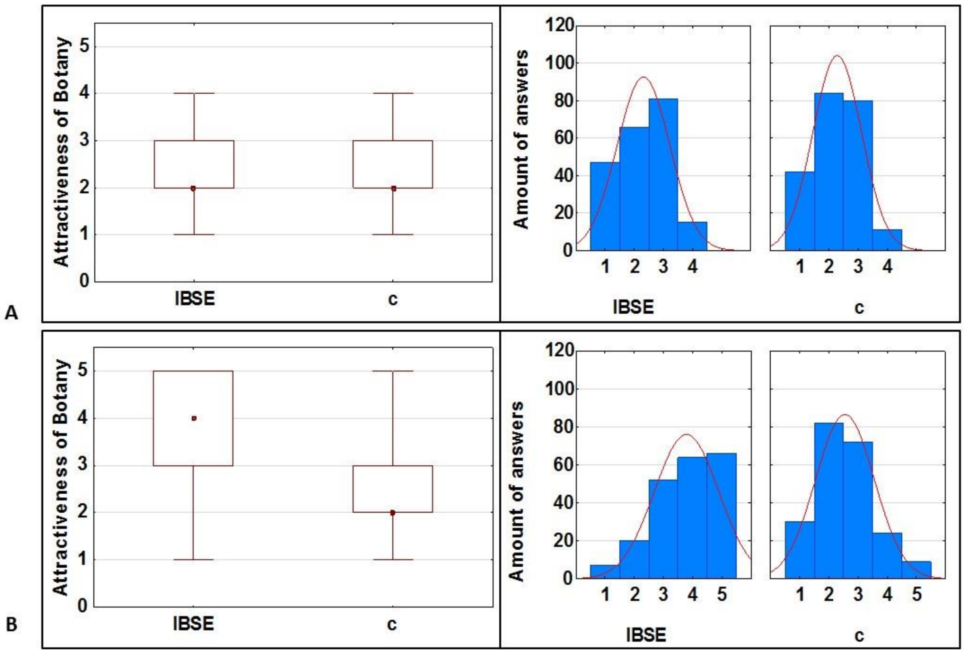

Fig.1 Students‘ assessment of attractiveness of botany learning and frequency of individual rating among the respondents (Likert type scale, grade 1= plants are boring, grade 5= plants are amazing) in pre-test (A) and post-test (B), n= 426. Small squares represent median values, boxes 25%-75% values, line segments min. – max. values. IBSE = respondents taught by inquiry approach, c = respondents taught by teacher centred approach.

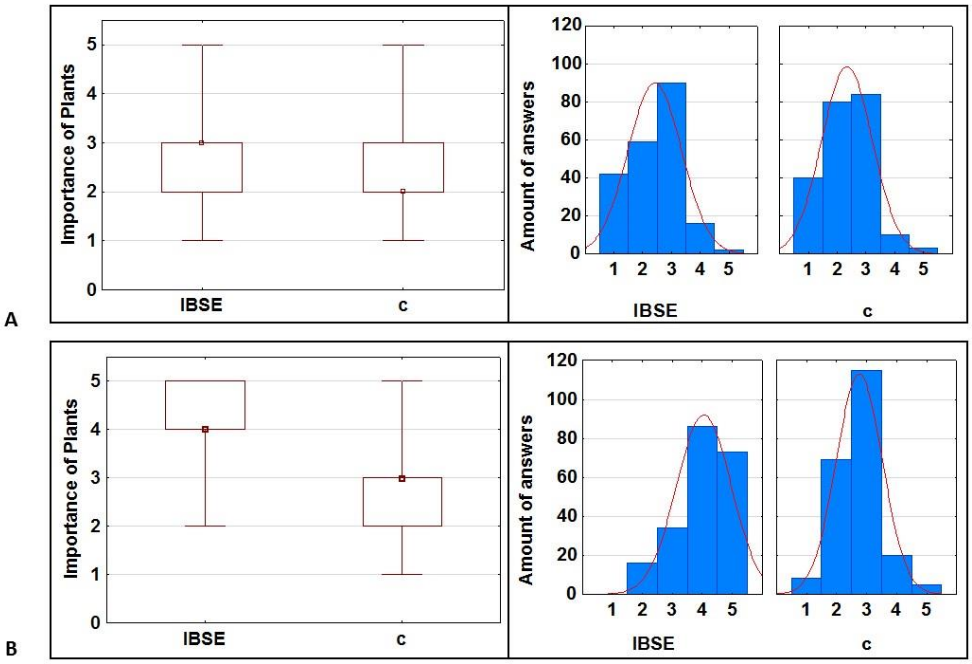

Fig.2 Students‘ assessment of importance of plants and frequency of individual rating among the respondents (Likert type scale, grade 1= plants are unimportant, grade 5= plants are very important) in pre-test (A) and post-test (B), n= 426. Small squares represent median values, boxes 25%-75% values, line segments min. – max. values. IBSE = respondents taught by inquiry approach, c = respondents taught by teacher centred approach.

As follows from the results of the post-test, teacher centred education did not influenced much the attractiveness of plants for students. Despite of the changes in the frequency of individual rating the median value remained unchanged, (see Fig. 1). On the other hand, for the respondents who absolved inquiry education, the attractiveness of plants increased from median value 2 to 4 and about 15 % of respondents considered plants even as “amazing” (grade 5).

The new knowledge obtained by any kind of education, inquiry as well as teacher centred, influenced positively students’ consideration about the plants’ importance, (Fig.2), but the reached score (median = 4) was significantly higher in the case of inquiry taught students according to the Kruskal – Wallis test ($p < 0.01$). The majority of inquiry taught students assessed the importance of plants by the grade 4 or 5, but for the conventionally taught students remained the plants after the absolved education just “middle important” (grade 3).

According to the analysis of the answers to the question 4 in the pre-test we can assume, that 13 -16 years students are not very well informed about the important functions of plants in our environment, because just three function of plants were named: The majority of the students considered plants as significant in our environment because of their production of oxygen (91% of the students). 31% named importance of plants as the source of food. Just one respondent named the importance of the tree for the removal of dust from the air. 2% of the answers were without any respond. No other function of the plats was named. Nobody from the students named any of the significant roles of plants in our atmosphere – neither assimilation of CO_2 from the atmosphere via photosynthesis, nor removal of atmospheric pollutants. Nobody knew for instance about the role of plants in water cycle in the landscape or cooling ability of the plants for surrounding air, etc. This is highly alarming, because these functions of plants are essential for the mitigation of the effects of atmospheric global changes, like for instance increasing dryness on the Earth. From this reason, scientists around the world pay a big attention to plant physiological processes related to our atmosphere. Unfortunately, there seems to be a big discrepancy between the real significant role of vegetation in humans' environment and the students' perceptions of this role. Hence, it is a big task for the educators for the future, to increase students' knowledge in this field.

Based on the analysis of the post-test, we can assume, that inquiry education impacted positively students' attitudes to plants. After the absolved education, the attractiveness of plants for the students increase significantly in focus group. Students of both group assessed the plants more important for our environment after the absolved education, but the increase of plants importance for the students was significantly higher in case of focus group (Fig.2). On the other hand, despite of the increased attention to plants, the preferences between plants and animals remained unchanged among 13 – 16 years old Czech students after the inquiry education. As showed the analysis of post-test, 88% of the respondents prefer animals before plants similarly as detected during the pre-test analysis.

In general, we can say, that students who took part in any kind of inquiry education included in this survey worked enthusiastic during the lesson. For 92 % of the respondents was the inquiry education interesting. As follows from the analysis of the post-test, there were more reasons for the increased attractiveness of the botany learning, than simply inquiry approach alone. Among the answers of the respondents four different. Based on the answers of the students, four main factors enhancing the attractiveness of learning for the students were defined: 1. working with technology (interactive whiteboard, measuring devices during outdoor education), 2. working outside, 3. making experiments, 4. possibility to discuss the results with the peers (see Tab1). The students, who attended a laboratory inquiry unit considered making experiments as the most exciting factor during the education. The majority of the students, who had a possibility to work with interactive whiteboard (IWB) during the inquiry lesson, considered as the most exciting the possibility to work with IWB, the possibility to make experiments was placed as the second. Similarly, the students, who took part in inquiry outdoor unit were excited first of all by the possibility to work with measuring technology. The second most attracting factor for these students was the possibility to work outside. Making experiments and discussing with the peers was analysed as the third resp. fourth one. Hence, besides inquiry, the students were also enthusiastic about the possibility to work with technology, and to learn outside. This finding correlate with previous results, documenting the positive effects of outdoor education on students' motivation, interest and attitude towards science education (Lindner, 2014) and positive impact of the use of technology on the implementation of inquiry education (Ryplova & Cekal, 2016; Ryplova & Rehakova, 2011). Therefore such activities could be recommended to attract the young generation to botany learning, which combine inquiry learning supported by technology with outdoor education. This is possible among others in project based education. The use of inquiry during project based education was already recommended by several contributions of this conference in previous years (Bilek & Machková, 2014).

Tab. 1 Factors of the attractiveness of learning as assessed by students taking part in different types of inquiry units. The values mean amount of students (in %) considering each factor as the most interesting during absolved education.

Attracting factors	Inquiry unit in laboratory	Inquiry unit+ IWB	Inquiry outdoorunit + technology
Working with technology	0 %	53 %	49 %
Working outside	0 %	0 %	34 %
Making experiments	52 %	36 %	15 %
Discussing the results with the peers	8 %	7 %	1 %
Other	4 %	0 %	0 %
No answer/ I do not know/ Nothing	36 %	4 %	1 %

CONCLUSSION:

Based on the results of this survey we can conclude, that inquiry approach enhance attractiveness of the plants for the students and improve understanding of the significance of plants in our environment. To improve the attractiveness of botany learning to students and by this way, to cope with plant blindness of young generation, inquiry approach in combination with outdoor education and use of modern technical devices is recommended. The survey discovered a big lack of knowledge of 13 – 16 years old Czech students in the field of physiological role of plants in our environment. In this direction further research is recommended.

ACKNOWLEDGEMENT:

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Contact address

RNDr. Renata Ryplová, Ph.D.

Katedra biologie
Pedagogická fakulta,
Jihočeská Univerzita v Českých Budějovicích
Jeronýmova 10
371 15 České Budějovice
e-mail: ryplova@pf.jcu.cz

PUPIL´S PAPER – THE PUPIL´S PROJECT AND THE TEACHER´S ROLE IN ITS PREPARATION

JELÍNKOVÁ Jana, RAJSIGLOVÁ Jiřina

Abstract

The contribution deals with an issue of pupils´ papers in biology lessons. The pupil´s paper plays an important role in education. Considering its specific framework and selection of the topics at least partly related to the common teaching themes, the pupil´s paper has the power to awake and keep up an interest of pupils in active participation in teaching process. The role of the teacher is also significant. The teacher has to provide information about how to prepare content and form of the pupil´s paper. This is connected with possibilities and evaluation methods of prepared pupil´s paper.

Key words

pupil´s paper, pupil´s project, questionnaire survey, primary school pupils, lower secondary school pupils

INTRODUCTION

In the concept of the pupil´s paper, pupils need to be self-reliant and engaged in taking an active role in their learning. The teacher performs the role of a guide. According to our assumption, significance of the teacher is essential for pupils at preparing their papers. The teacher should influence favourably the pupil by providing suitable motivation and explanation of sense of the pupil´s paper but also by his support during the pupil's paper preparation and by proper evaluation. The elaborated paper should be original, with personal approach and the pupil´s own contribution. The teacher should lead the pupil to the creation of the high-quality paper.

In agreement with the authors mentioned below, benefits of the pupil’s paper for pupil's learning follow. Pupils learn:

- how to gather the pieces of information from available resources, how to compare them with each other, how to evaluate their validity and classify them (Adámková et al., 2015);
- working with text as a basic assumption of reading literacy (Palečková et al., 2010);
- how to project their experience and opinions which underlie the unique approach and originality of created pupil´s paper (Maňák, Švec, 2003);

- by self-education: they look up and process the information by themselves (Pecina, Zormanová, 2009);
- developing of speaking and presentation skills (Kratochvílová, 2011).

The above mentioned benefits for pupil´s learning are in accordance with current trends in education that include active participation of the pupil in teaching process, delegation of responsibility for teaching to the pupil. The teacher has a role of a guide, advisor or couch. When the pupil chooses his or her own theme, their relation to given issue is encouraged and awaken. Another advantage is that pupils use the same way of speaking, the same language, the same expressions, colloquial expressions, as their peers; the pupil´s paper corresponds to the principle of peer-based program when children learn from each other. In this connection we can find subsequent reasons of why to teach pupils how to prepare a good pupil´s paper: the pupil´s paper or PowerPoint presentation are the most often outcomes of project based education. Therefore it should be continuously developed the skill of pupil´s paper preparation. The principles and theses of project based education, reflecting also the components of working on the pupil´s paper, could be found in various publications, e. g. by Blumendelf, P. C., et al. (1991); Chin & Chia, 2004; Kolková, 2012; Rusek, Dlabola, 2013, and others. The appropriate publications present factors and principles which are considered to be a basic assumption for project based education. They are also in compliance with principles of project based education when pupils currently use the skills gained from working on the pupil´s paper. Hand in hand this background it is important to state that all ways of the educational process must be consistently reflected and evaluated. Rajsiglová (2017) states the importance of the reflection and the evaluation as the partial and key skills of the teacher´s teaching and pupil´s learning.

Unequivocally, the pupil´s paper can be regarded as fulfilling preparation for many forms and methods of teaching and learning in classes, e.g. group learning, project based learning, problem-solving tasks, peer-learning, cooperation in groups, individual assessments, and the pupil´s paper can be considered as an individual real *pupil´s project* (Rajsiglová, 2017).

On the other hand, the surveys and existing research literature on the subject presented in the article contain notices and information of a general characters connected with pupil´s paper. The literature highlight and point to the problems e.g. of the origin and the authenticity of pupil´s paper, using of a sole source or the pupil´s paper as an internet order (e.g. Pavlasová, 2013).

Last pointed idea is relevant and represents the critical points of pupil´s paper; nevertheless the literature does not offer sufficient information and directions for teachers how to eliminate and to avoid the critical points mentioned above.

AIMS AND METHODS

The main aims of the paper are: 1. to determine when primary and secondary school pupils have met a method called pupil's paper for the first time during a school attendance; 2. what activities occupies much of the time for pupils to prepare the pupil's paper; 3. what is the teacher's role during preparation of the pupil's paper.

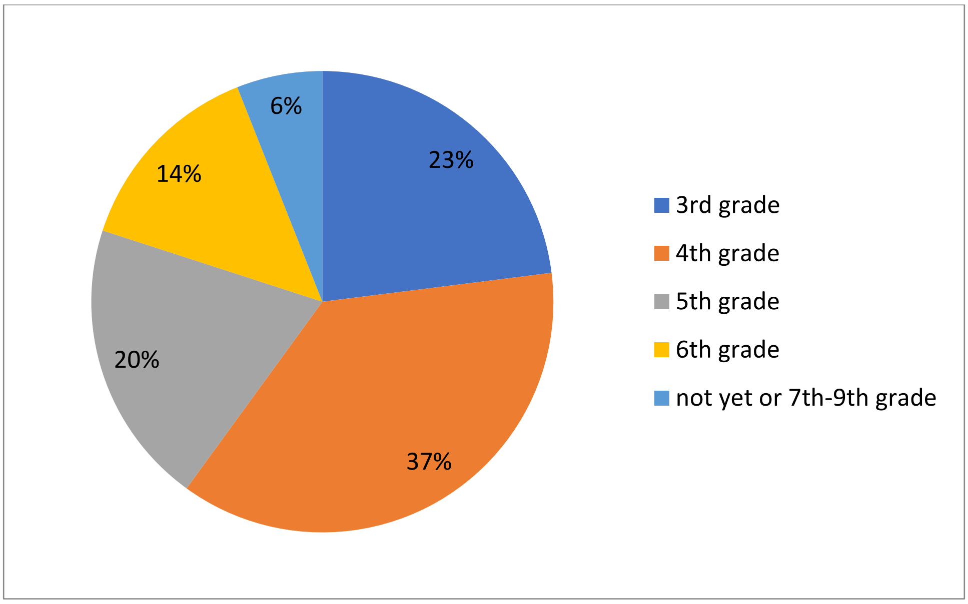
The results of this paper were obtained from a questionnaire survey carried out in the spring of 2016. The questionnaire was assigned by the one of the authors or author's colleague; in view of the fact the return of distributed questionnaires was 100%. The number of respondents was 221, represented by primary school pupils and lower secondary school pupils from three non-Prague schools.

The survey was carried out during biology lessons with regard to authors' teaching qualification and pupils were asked on a general questions represented by following battery points: in which grade have they personally come across the pupil´s paper for the first time - whether as its author or as a learner; what activities occupies much of their time at preparing pupil's paper; if they obtained from teachers the criteria for evaluation of pupil´s paper (propriety of content, time limit, speaking without notes or the possibility of reading the text, eye contact with the audience, etc.); who explained them (or if teachers to clarify it) the content of pupil´s paper (specific topic and how to keep it going, accuracy and depth of information, length of the paper – minimum amount of A4 text pages, pictorial material, personal experience); if they obtained an explanation of how to prepare for the pupil's paper (e.g. use of at least 3 information sources, logical arrangement, interestingness of the information, time schedule – a preparation outline) or if they obtained an explanation how to present your pupil's paper (understandability, pace, vocabulary, extemporaneous speech, notes only as an auxiliary source of the information, ability to answer the questions, eye contact, relaxed pose).

The survey results were analysed and then evaluated using column charts and pie charts.

RESULTS

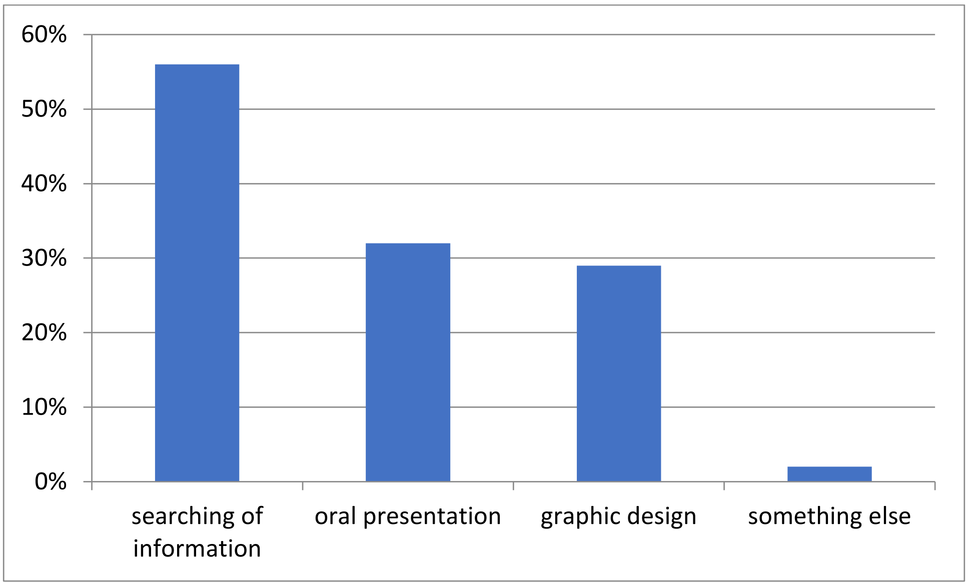
The crucial three conclusions of the presented survey in relation to the objectives set out in the article are: firstly, pupils are familiar with the pupil's paper during primary school – they often begin with their pupil´s paper in the fourth grade of primary school (37 %) and at the latest in the sixth grade of primary school (14 %). Only two percent of surveyed pupils have not come across the pupil´s paper yet during their education (Graph 1).



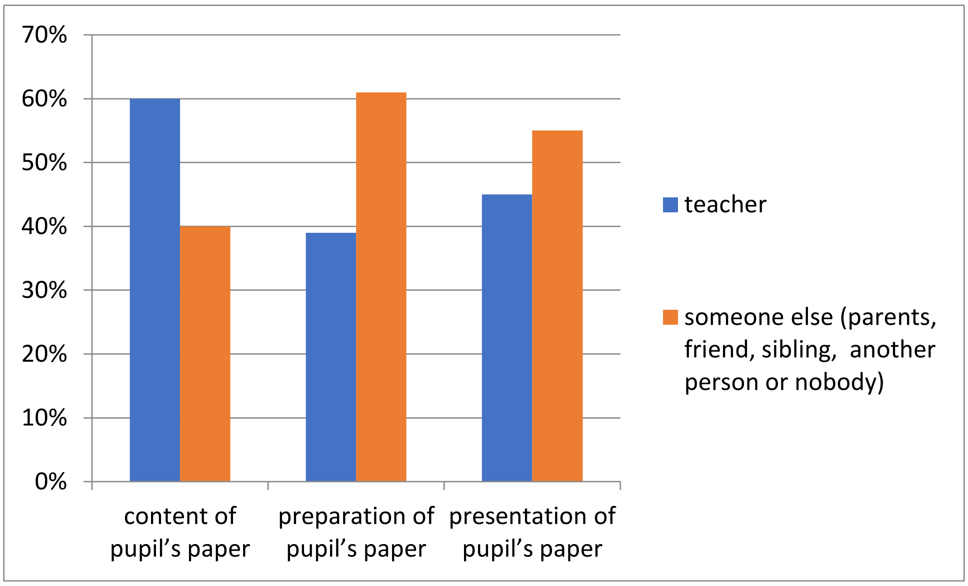
Graph 1: The first encounter of the pupil´s paper during school attendance, source: Jana Jelínková, Jiřina Rajsiglová

Secondly, pupils who have already had work experience with preparation of pupil's paper are concentrated on the pupil's paper content, especially for searching of information. Consequently it can be stated this pupils pay little attention to the processed form, they pay almost equal attention to prepare the activity of oral presentation or graphic design as it is shown in Graph 2.

Finally, graph 3 demonstrates the role and help of the teacher at specification of the pupil´s paper. Almost a third of the respondents (32 %) obtained no information about content of the pupil's paper, which means range and depth of information, length of the paper – minimum amount of A4 text pages, pictorial material, figures or personal experience. Half of the respondents (51 %) did not hear the teacher's information about how to prepare the pupil's paper, especially considering the sources and literature. Nearly half of the respondents (48 %) obtained no information about how to present their pupil's paper.



Graph 2: The activities which occupies much of pupil's time at preparing pupil's paper, source: Jana Jelínková, Jiřina Rajsiglová



Graph 3: The influence of the teacher on explanation of content, preparation and presentation of the pupil´s paper to the pupil, source: Jana Jelínková, Jiřina Rajsiglová

DISCUSSION

The teacher is the person who introduces for the first time the pupil's paper into lessons. As Graph 1 shows, pupils very often come across the pupil's paper in primary school. Only 2% of the respondents have no experience with the pupil’s paper.

In connection with the Graphs 2 and 3 it can be noted that pupils have not fully-fledged information and requirement how to prepare the pupil's paper in its whole complete form. Pavlasová (2013) appeals teachers to require their pupils they to use the various information resources more extensively, afterwards teachers should control the resources. Last but not least Pavlasová (2013) recommends pupils to compare information and formulate own opinions.

The teacher usually proposes the topics of pupils' papers in relation to the concrete subject discussed in school but the pupil can also suggest an interesting and original theme. The pupil's paper belongs to the tasks elaborated by pupils themselves. The teacher's explicit specification is a necessary condition for successful execution and completion (Kotrba, Lacina, 2015) – and here we take notice of some reserves that can be work on in school practice. It is the task of the teacher to provide accurate information so that the pupil knows in advance the demands, purpose and meaning of the pupil's paper, and to recapitulate generally valid instructions for preparing the quality paper. Besides, the pupil should learn from the teacher: is the purpose of the pupil's paper to inform about given topic or to convince about the issue or to analyse given theme.

Generally stated, the pupil´s paper is a well-structured summary of the information on a given topic for a given type of listeners. According to the results of our survey and also in agreement with the definition by Adámková et al. (2015), Palečková et al. (2010) or Pecina, Zormanová (2009) we can highlight the necessity of giving attention to how pupils could find, organized and present the information in each field of education, since the requirements and criteria of individual teachers could vary and the pupil should obtain complex information about preparing of the good-quality pupil's paper whenever s/he is going to elaborate it.

Following questions arising from our survey should be asked by us as teachers whenever we submit pupils' papers to our pupils: What exactly do we demand of pupils when we set the task to them? How can we check the compliance? Why do we actually assign the pupils' papers?

CONCLUSIONS

This contribution introduces the issue of the pupil's paper. The initial impulse for the research came from biology lessons. Our survey was carried out in biology lessons with regard to authors' teaching qualification, however we assume that the results of presented quantitative pedagogical research are of general application as the pupil´s paper is used within the teaching process not only in various science subjects but also in art or music classes or electives, and criteria for its preparing and presentation are valid across all educational disciplines.

Based on the results of presented survey we are of the opinion that the role of the teacher is irreplaceable during pupil's planning and preparation of their pupil's paper. The teacher has to provide comprehensive information about how to prepare content and form of the pupil's paper and also how pupils should present the prepared information to their schoolmates. This also includes the theme of evaluation; teacher should inform his / her pupils what the criteria of a good pupil's paper are.

Just mentioned is a prerequisite for achieving pupils' success in preparation and presentation of a high-quality pupil's paper. Pupil's paper presents pupil's project and all learnt experience during work on its preparation could be used in various methods and forms, e.g. project based learning or group learning, nowadays well established in the school classes.

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Contact address

Mgr. Jana Jelínková, Ph.D.[1], RNDr. Jiřina Rajsiglová, Ph.D.[2]

[1]ZŠ T. G. Masaryka Mnichovice,
Bezručova 346,
251 64 Mnichovice
e-mail: jjelinkov@seznam.cz

[2]Department of Education and Didactics of Biology,
Faculty of Science,
Charles University
Viničná 7,
128 43 Prague 2
e-mail: jirina.rajsiglova@natur.cuni.cz

QUALITATIVE RESEARCH ON THE ATTITUDES OF HIGH SCHOOL STUDENTS TO THE WHOLE SCHOOL PROJECTS

CHLEBOUNOVÁ Irena

Abstract

The aim of this research was to find out the reasons of the attitudes of the high school students to the whole-school projects. The three groups, which co-operated on the same sub-theme, answered three questionnaires and the supplementary questions. One group underwent a recorded interview. The methodology was in accordance with the grounded theory. In total, 58 students from the first to seventh grade were included. It turned out that their interest depends on experiences with similar projects, the motivation of teachers, and the feeling that the project is meaningful.

Key words

Project based learning, motivation, practical work in science

INTRODUCTION

According to the research conducted by Pouchová (2010) in 2009 and covering 180 Czech and 71 Slovak schools, "one fifth of Czech and Slovak teachers admitted that they struggle with students lacking interest in the project-based education." Only 7 % Czech and 17 % Slovak teachers considered projects popular among teen-aged students.

To see students enjoying their work, satisfied with its outputs, and keen to participate in future projects, the teacher has to bear the responsibility for the entire project and, directly or indirectly, control its development. The teacher becomes the source of motivation, mentor, supervisor, and coordinator, a person always ready to answer students' questions and provide help (Šulcová, Pisková, 2008).

The aim of this qualitative research was twofold: (a) to find out, with the help of grounded theory (Strauss, Corbin, 1999), the attitudes of teen-aged students to whole-school projects; (b) to propose (on the basis of the output of (a)) improvements in the design of future whole-school projects. The grounded theory was chosen because it can describe the dynamics of processes. "It shows how changes in conditions influencing negotiation or interaction lead to altered responses of acting persons." (Švaříček et al., 2007, p. 86). It is probably also the most elaborated design of qualitative research which could be combined with quantitative methods.

(Švaříček et al., 2007). To reveal the evolution of students' attitude towards whole-school projects, the research revolved around the basic question: How is the experience of students with previous projects related to the expectations in the current or future projects?

METHODOLOGY

School and project characteristics

The data were collected at an eight-year high school in the center of Prague during the Pila project in January 2017 (Pila 2017). The author taught the second year of chemistry and biology, she was a class teacher of the second grade students, and, in the Pila project, the leading teacher of the topic Air. The Pila project comprised eight topics: Purity, Safety, Light, Noise, Air, Concentration, Nutrition, Movement.

The whole-school Pila project was based on the proposals of the representatives of all the classes, who regularly meet at the pupils' council. They were elected representatives of students' opinions. The aim of the project was to increase students' competence in problem solving through carrying out a survey of the eight above mentioned problematic areas of the school, to propose changes to the school that would be based on the results of the student research, and to defend the proposed changes before an official jury composed of members of the school council and other selected representatives.

Students worked in thirty groups, each of about 16 pupils from all grades. They learned competence in problem solving, one of the pillars of this Catholic school's educational program. Each topic was dealt with by three to four independent groups. After a week's work, each group produced their presentation of the results they had reached. Students of groups working on the same topic then met, together created the final presentation, and then defended it during the second week.

Sample of students and analyzed documents

Four different sources of information expressing the views of high school students were analyzed. The first source was a questionnaire filled out by the team members. The questionnaire combined both opinion questions with responses rated in a four-point Likert (1932) scale (1 = Strongly Agree, 2 = Agree, 3 = Disagree, 4 = Strongly Disagree) and open questions. The students were asked whether and why they were satisfied with the outcome of their work, whether they understood the job assignment, how intensively they cooperated with the teachers, what support they needed for their team, and how they would better organize their work the next time.

The second source was a semi-structured interview with a group of twelve pupils of different age. They were given the opportunity to comment on what seemed most important to them. They talked about previous projects, about what they consider a good project, what bothered them in the projects that they considered bad, and they also talked about their opinions on teaching science.

The third source was a questionnaire with open questions for three groups working on the topic Air with the assistance of another teacher. The questions asked how the members of the different teams evaluated the meaningfulness of the whole-school project as well as the sub-topic, why they chose the topic, and whether they see the benefits or weaknesses of project-based learning. A total of 31 students of all grades answered these open questions.

The fourth source was a questionnaire combining again open as well as opinion questions (Likert four-point scale) and applied in the second grade class. In it, students had to express what they had learned through the project lessons, what project activities they would like to include into the curriculum and what they would like to do in a next project. A total of 27 pupils responded to the questionnaire. These students were divided into different groups and topics during the project. This class was chosen because these students experienced only the last two high school projects, so their opinions were not influenced by the older projects. (J. A. K. 2016, Strom 2015, Živě rozvinout tradici 2014)

Analysis according to grounded theory

An open coding was used, so a code was to assigned to each statement (e.g. *R51H1 The idea to try to improve the school environment seems interesting to me; R512H4 I therefore personally consider project training to be very inefficient in terms of time requirements*) and such statements have been include into one category (a more general term).

E.g., the category "Theme" comprised: *R51D5 The topic is good,R51D22 The teacher is more important than the topic, R51D6 14 days is too much, the work can be done in one day R51D4, The topic is too difficult for me, R51D9 I will choose another topic next time.*

By means of the axial coding, the relationships between the categories were searched for and, consequently, a paradigmatic model was created (the diagram in Figure 1).

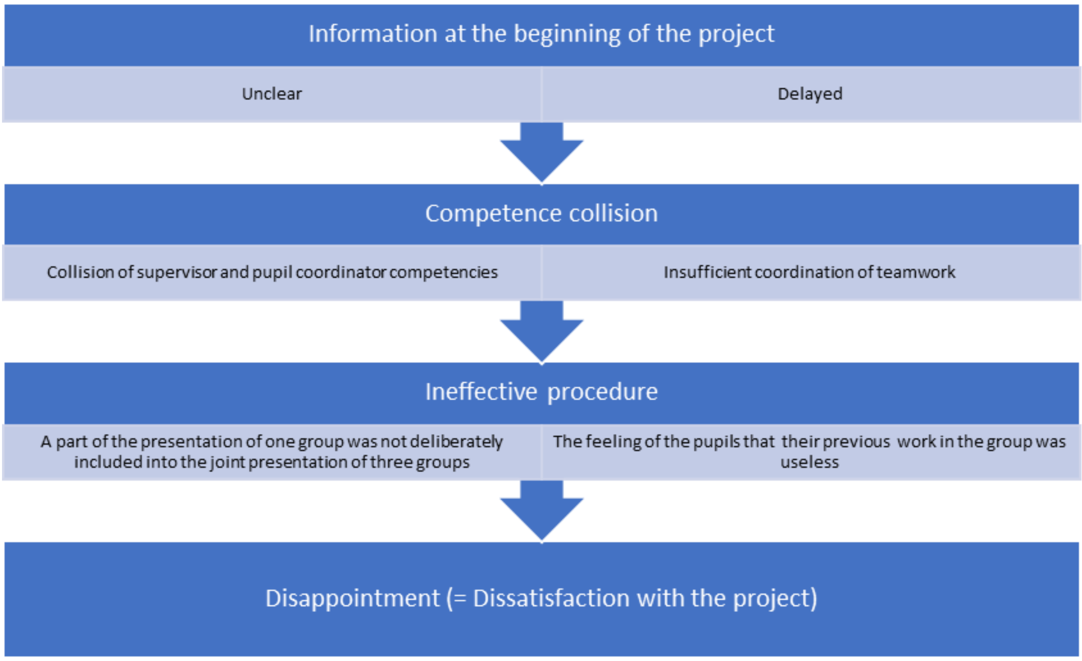

Fig. 1 Explaining the relationship between a phenomenon (collision of competencies), causal conditions (information from school management), context (collision), intervening conditions (ineffective procedure in working with teams), strategies of negotiation (omitted information) to the consequences of this behavior from group work and from the project), source author

RESULTS

In the selective coding phase, the "**satisfaction with the project**" as the central category was identified and linked to all the other categories. In the diagram in Figure 2, for the sake of clarity, subcategories are not listed.

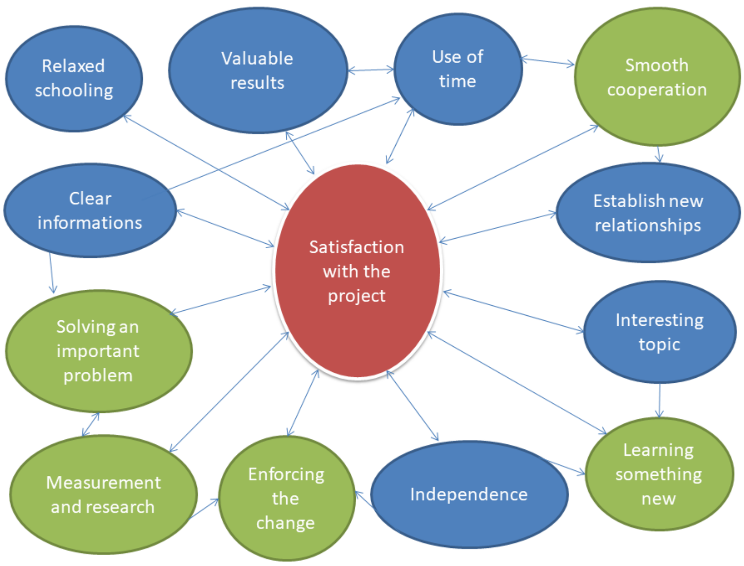

Fig. 2 Relationship of the central category (red) and other categories (green marked were mentioned by all groups of students, blue only by some). Source author

A difference between older and younger students showed up. The seventh grade students (17 years old, the longest experience with the whole-school projects) expressed their skepticism about the possibility of changes in school environment based on their suggestions. They also complained that the search in literature had been too difficult for the younger students in the group and that they (seniors) had had to help them substantially. Senior students emphasized the importance of (a) the attractiveness of topics, (b) smooth cooperation with the supervising teacher, (c) the efficient use of time that includes both comprehensible guidelines provided by the school management and clear research priorities formulated by the project participants. They wanted more influence on the organization of the project.

The conclusion is that the attitude of students to the projects develops depending on their experience with project-based learning. This view is based on the questionnaires and on a number of informal conversations with both, students and teachers.

The youngest students considered important that, through the project, they learned something new about health, safety, or their school. They also appreciated other forms of teaching, the skills they acquired, and the outputs they obtained through the project. They wish to make a student film during the next project. It was clear from the responses that, regardless of the age, the students are aware of the benefits of the projects, although some students do not enjoy their participation in the projects.

DISCUSSION

What is the main thing that connects the last four whole-school projects at the observed school? The students were excluded from the preparation of these projects and this decision of school headmaster lead to their poor motivation during all project activities. Students recognized meaningfulness of some activities, but they did not go along with the idea of the projects. So we can see that breaking of one project rule can decrease the students' satisfaction with the entire project.

"In project-based teaching, the pupil's inner motivation is the most important condition of success. Therefore, projects initiated by children themselves are often more successful." (Nováková, 2010, p. 18) In this statement, I find the key problem of the student attitudes to the Pila project. Even though the project ideas came from the students, the organization was run by the school management, so the students did not identify themselves with the problems they had originally wanted to solve. In the interview, the students expressed their astonishment about why they should support their proposals for the improvements of the school by scientific research, if a poll among classmates and teachers would be enough.

(See R51D34 Most of the changes that should be made here first know and secondly, there is no need to subdue them with scientific work ... And if we do not mind it, it just has to change and it does not matter if someone did or did not do a scientific work!) There was also the inconsistency between teachers. Many of them considered it as a waste of time, which was also passed on to students. The motivation not only of students but also of their teachers was underestimated.

According to Vítková (2011, p. 65), the most frequently mentioned project constraints are time consuming and difficulties in evaluating, while the motivation is, among other things, the pupils' knowledge in situations other than in regular lessons. In an interview with students, the idea was repeated that fourteen days are too long to stop traditional teaching and to devote one project. This was the reason why some called project-based learning as ineffective. (See, for example, *R514D2 There is a problem that the project takes a lot of time*.) On the other hand, one girl from the second grade was excited by the idea to change her role with teachers so that these two groups could understand each other better. (See *R517D3 That teachers would know what it is and the students would find out what it is for those teachers.*)

"A good project should primarily attract and excite pupils, differing from the regular style of learning, teaching pupils to work together and being responsible for their work and for the whole group, showing pupils continuity ... allowing pupils to gain new experiences that cannot be taught in any subject, pupils should experience new situations and seek solutions. "(Balharová, 2010, pp. 1-2) According to this definition, Pila's project underestimated the initial motivation of students. The oldest students stayed at home and the others felt intellectually weakened. In the case of seventh grade students, this led to their decision not to participate in the project next year.

"As an appropriate motivation to raise the interest of pupils in solving the project, it has been possible to present their results on a whole-school scale ..." (Šulcová, Pisková, 2008, p. 15). Presenting their work and its results to various listeners was a prerequisite for successful finalization of the Pila project. Students themselves appreciated the quality presentations that arose in their team or which they saw to advocate other students. On the contrary, some rated the project with a worse mark because they were not satisfied with the quality of the presentation of their team and most often because they did not identify themselves with the quality of the resulting presentation, which was made up of three groups of one theme together. That is why I think to make one of the three presentations one day during the one day cooperation was demotivational and damaged the quality of the outcomes of the whole-school project. I also prefer our team presentation than the result that the representatives of our three groups advocated before the school council.

Švecová recommends that the funds to cover the cost of solving the project are sought by the school through a grant. (Švecová, 2012, p. 45) A large part of the students' disappointments are related to the fact that there is no money to implement their suggestions, and they feel that the research in the project was meaningless when their proposals after the end of the project will nobody accept.

CONCLUSION

The conclusion is that the attitude of students to the projects develops depending on their experience with project-based learning. This view is based on the questionnaires and on a number of informal conversations I had had with students.

The category **"Satisfaction with the project"** reflects the feeling of students that they have solved an important problem, preferably with the help of practical measurement and field research. In the beginning, they got clear information, they could choose a topic that they are interested in and the group they will be working on. As a result, teamwork worked well, effectively utilizing time, even though students enjoyed schooling more relaxed than in regular classroom lessons. Students have established new relationships between classes. Through the teamwork, they were able to show their self-reliance. They have learned something new, created a product they are proud of, or they have succeeded in pushing for a change.

What should be the main focus of organizers of the whole-school project? First, get an interest in the project among teachers. Second, do not start work on the project until the students get involved. Always take their ideas seriously. Third, let creative students take initiative and responsibility. Fourth, properly and publicly appreciate students' presentations and other achievements. Try to show them how to get money for a good proposal and how to get it done.

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Contact address

RNDr. Irena Chlebounová

Department of Teaching and Didactics of Biology
Faculty of Science,
Charles University
Viničná 7
128 43 Praha 2
e-mail: chleboui@natur.cuni.cz

PROJECT BASED LEARNING AND OTHER METHODS AND FORMS USED BY PRAGUE TEACHERS SUPERVISING PEDAGOGICAL TRAINING IN SCIENCE LESSONS

RAJSIGLOVÁ Jiřina

Abstract

This paper presents a questionnaire survey - a study into the use of methods and organizational forms in common practice of secondary school teachers, with particular regard to the author's certification in chemistry and biology. The survey was carried out twice, the second one after eight years after the first one.

Within the survey, respondents were asked to indicate if they implement particular methods and forms into the teaching process. The questionnaire is focused on following methods and forms: project based learning, group learning, excursion (field trip), creative writing, mind maps, peer learning, role playing, brainstorming, exposition (interpretation), lecture, laboratory practice, demonstration experiment.

Key words

Project based learning (PBL), methods of teaching, organizational forms, science teaching, questionnaire survey

INTRODUCTION

In the 21st century, new requirements are posed on graduates of different types of schools, because the ability to find a job during their lives depends not only on whether a person receives appropriate skills but especially on whether they have a sufficiently wide general and professional base of education and the key competencies that are necessary for work and enable easier retraining (Kolková, 2012).

According to The Framework Educational Programme (2007, p. 10), the key competencies represent "the system of knowledge, skills, abilities, attitudes and values that are important for the individual's personal development, his or her active participation in society and future success in life". Within The Framework Education Programme for Secondary General Education (Grammar Schools) (2007), a pupil should acquire learning competencies, problem-solving competencies, communication competencies, social and personal competencies, civil competencies and entrepreneurial competencies. Within The Framework

Education Programme for Elementary Education (2007), entrepreneurial competencies are replaced by working competencies.

The requirements of RVP ZV (2007) and RVP G (2007) promote the diversity of the approaches to teaching and learning range from a general requirement to use alternative methods, to further concrete measures to promote their development, validation and acceptance in school practise. The change of the teaching style in schools should also contribute to and support the development of the competencies because the competencies are based on activities, not only on knowledge.

To teach the pupils how to communicate, solve problems, to confirm the ability of pupils to learn, to teach them how to acquire and seek information that can be used further in practice - these are the objectives proposed nowadays by many educators (Kolková, 2012; Rajsiglová, 2017).

For the above reasons and considerations as well as natural continuations of previous work of the author (Kolková, 2012), research into what different methods and forms are used in school practice, the main goals of the article are:

1. To introduce the most often used methods and forms by Prague teachers supervising pedagogical training in the science lessons;

2. A comparison of two questionnaire surveys carried out eight years apart: How have after the eight years changed implementation of teaching methods and forms in science lessons of Prague teachers supervising pedagogical training.

Prague teachers with particular regard to certification of biology were asked in the questionnaire research.

THEORETICAL BACKGROUND

Schools have numerous responsibilities which include but are not limited to teaching the students' observation, sorting of information, critical thinking, communication, presentation of outcomes and problem-solving skills. Science, properly taught, can help schools fulfil these responsibilities because students can apply the knowledge and skills learned within their school subjects to solve practical and also theoretical problems in their science classes (Balasubramanian & Wilson, 2007).

Actual view on teacher's role in educational process

As a result of curricular reform since the end of the 2000s, it might seem that during the last two decades the role of teachers in Czech schools has changed. However, in spite of all efforts to change the view of a teacher's main role in educational process in the Czech Republic, the general view still remains that the main purpose of a teacher is to be in the centre of the whole educational process. This can be witnessed especially at secondary schools (rather than primary schools) where the word *teacher* corresponds with *the one who transfers the knowledge, the authority who presents the facts to remember and to write down.* The teacher is predominantly in the centre of school lessons and decides what, when a how the pupils will learn (compare Kolková, 2012; Málková, 2010).

With the educational processes evolving and with more importance being given to active and hands-on approach in students' roles in their various educations the role of a teacher also needs the transform. A teacher needs to become a mentor offering guidance, a promoter, a manager, facilitator and corrector in one. Teachers should guide pupils to be more responsible for their own learning, let them to learn by peer-learning, by cooperation in groups or by individual assessments. Teachers should try to bring new methods and forms into classes and also introduce (more) creative atmosphere to their lessons. The system changes step-by-step, the exchange of scenarios of lessons, established manners and ways in practice and the new roles of participants of education are slowly accepted. Nevertheless, ever greater percentage of teachers understands and emphasises their role as a guide, advisor, facilitator or *middleman* in the educational process (compare e.g. Grant, 2002; Kolková, 2012; Rajsiglová, 2017; Veenman et al., 2003).

In connection with this new role of a teacher as a supporter and a guide, a special term frequently appears in English literature - *scaffolding teaching*. An example of scaffolding teaching would be the encouragement of pupils to ask questions, to formulate own hypothesis, to draw evidence-based conclusions, to cooperate and to discuss with each other. The participants would debate and play active role in moderating their debate with the option to ask their teacher or peer for help if needed. Working sheets and good working conditions and environment among others should be provided by the teacher, as well as any other support that would bridge any gaps in pupils' skills and knowledge and make their tasks achievable (compare e.g. Bell, 2010; Grant, 2002).

This should result in students being the main active element in their own education, with the teacher leaving the learning activity mostly on the pupils and providing an adequate support where and when needed. The new role of a teacher implements not only the ways of teaching, but it also includes relationship aspect as the teacher should create an affiliation to their pupils and also to themselves. A teacher's role on this level would naturally change during the shift from classical, frontal (represented by teacher's distance from pupils) to teacher as a guide (with the use of various methods and forms of teaching).

Activating of pupils

As mentioned above, one of the most noticeable changes in nowadays educational system is the shift (or at least partial shift) in responsibility and hands-on approach from teacher to pupils during a lesson. Yet another one is the aspiration to move from frontal teaching to other forms, such as teaching-learning collaboration and pupils' cooperation in lessons. Only active pupils' participation in the educational process enables proper effective learning. According to the constructive teaching school of thoughts, keeping pupils' attention active during lessons will enable genuine educational progress (Krajcik & Blumenfeld, 2005).

The need to teach pupils to settle the tasks associated with solving problems (so called *problem-solving tasks*), act and think autonomously and also evaluate their own learning is reflected in implementation of *problem tasks* into education. Problem tasks inspire both teachers and pupils to seek improvement and take ownership of their learning processes. The essential character of *problem-solving tasks* can be traced in a whole range of methods, so-called *activating methods*, pupils' centred methods, utilised, inter alia, also as a part of group learning or project based learning (compare Chin & Chia, 2004; Grant, 2002; Krajcik & Blumenfeld, 2005).

This paper compares activating pupils' centred methods and traditional methods and forms introduced in following chapter.

SURVEY'S DESCRIPTION

Methodology - methods and forms watched in the paper

The survey carried out twice, the first one took place on the spring 2009, (N=51 of those questioned), the second one on the spring 2017 (N=44 of those questioned), and respondents were asked to assess if they implement particular methods and forms into the teaching during the school year; teachers tick off yes or no under each method or form. In the case of ticked yes, they estimated the use of particular method or form during the school year. The data received in the framework of this article are evaluated in relations with yes or no answers.

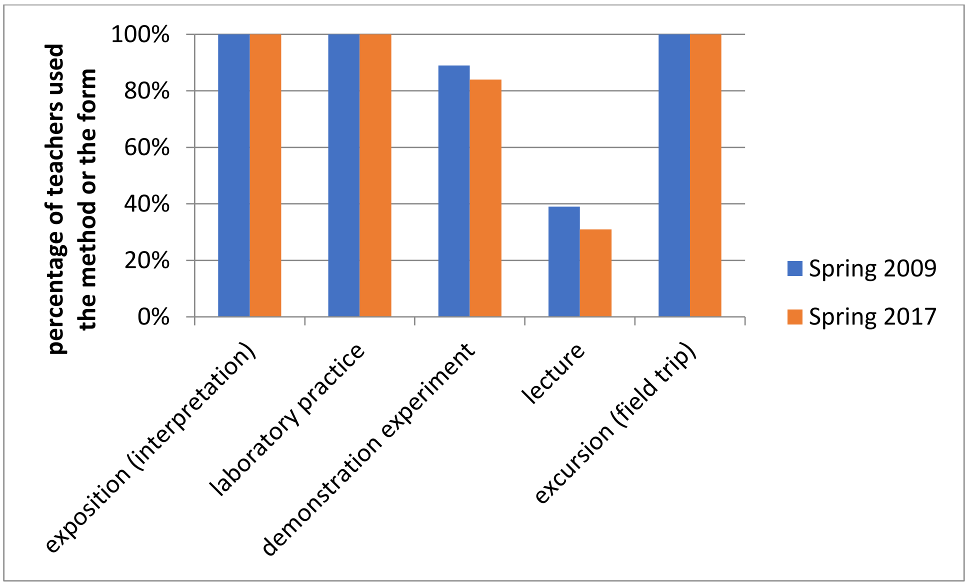
The relevant questionnaires were sent in envelopes by students during pedagogical practice training. In order to ensure the anonymity of the teachers we do not ask teachers' names. Both researches were concentrated on teachers supervising pedagogical training in science lesson, especially in biology; because of anonymity the forms cannot be associated in pairs in two researches and it is not possible to decide which forms are single in the case of the previous or new supervising teacher.

The following methods and forms presented in the article are: project based learning, group learning, excursion, exposition, lecture, creative writing, mind maps, peer learning, role playing, laboratory practice, demonstration experiment.

If the methods and organizational forms are divided into two groups in accordance with Kolková (2012), the first group presents traditional methods and forms - exposition, with the meaning of an interpretation, laboratory practice, demonstration experiment, lecture, and excursion, the second groups presents activating methods and forms (to be interpreted as meaning of contemporary, modern used methods and forms with pupils in the centre of learning) - group learning, creative writing, mind maps, peer learning, role playing and project based learning.

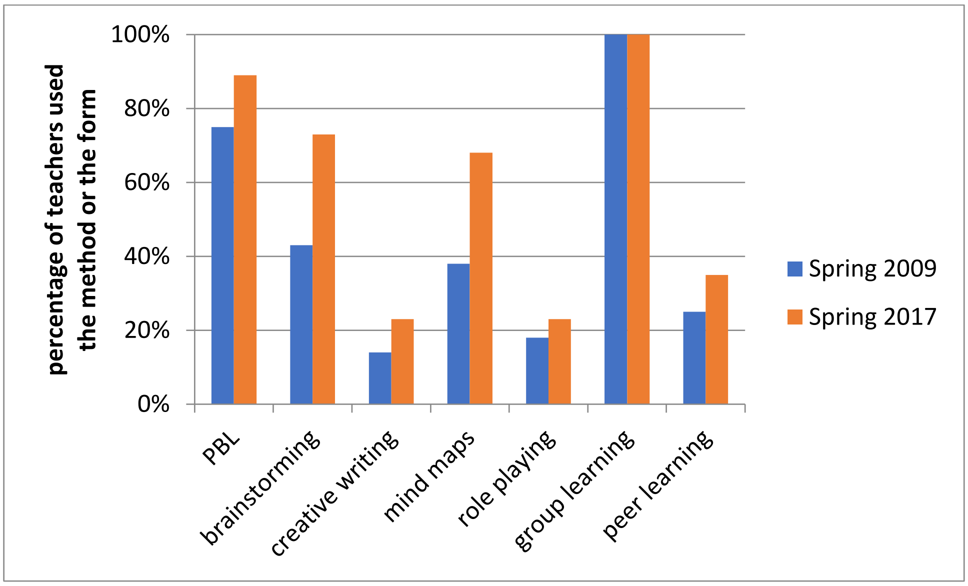
Graphical processing of the results

The results of comparison of both surveys in the first group ranked methods and forms used by teachers are available in the graph 1.



Graph 2: The comparison of using traditional methods and forms, source: Jiřina Rajsiglová

The results of comparison of both surveys in the second group ranked methods and forms used by teachers are available in the graph 2.



Graph 2: The comparison of using activating methods and forms, source: Jiřina Rajsiglová

Comment of the results

Not surprisingly, results of both surveys indicate that all of teachers used most often the traditional methods and forms defined in the first group, especially the exposition, the laboratory practice, and the excursion it is in 100% of cases. As a complement to this, the group learning is also used in all the teachers' lessons.

With regard to the laboratory practice, the form where pupils work in group of two or three, there is no doubt teachers integrate *group work* into the classes. In relation to the detected fact would be interesting to examine the effect of cooperation during the group work and learning and to distinguish between differences of just *group work* and desirable *group cooperating learning* that implies cooperative ways of working.

The comparison of the presented researches shows that have increased the using of the activating methods in last eight years. Teachers from the second research integrate project based learning, brainstorming and mind mapping into their lessons more often compared with the first research. Creative writing, peer learning and role play have less intensive effects of using in school practise.

DISCUSSION

Most of the knowledge acquired through lecturing is forgotten rapidly. The use of modern educational approaches to promote lifelong learning becomes necessary. Teachers have currently sufficient freedom and liberty of choosing educational methods and forms to be used to attain its objectives in the lessons (Kolková, 2012).

One of the most significant current discussions in education is how to incorporate different methods and forms, not only traditional, into the teaching, with a view to understanding the variety of factors leading to benefits for both teacher's teaching and pupil's learning (Kolková, 2012; Krajcik & Blumenfeld, 2005; Veenman et al., 2003).

To identify the causes of lower representation of activating methods and forms and their potential consequences for pupil's learning we can consult the different experts' publications. In accordance with them, e.g. Grant, 2002; Chin & Chia, 2004; Kolková, 2012; Rajsiglová, 2017, author of the paper agree that using of alternative activating methods and forms is more demanding in initial preparation of the lessons, needs a better understanding of the relationships between pupils and teacher and a better understanding of the every single method and form and so on.

In spite of higher extent of using of methods and forms traditionally used in the science lessons, after eight year since the first survey, the increased number of the activating methods and forms can be observed. Nevertheless author of the paper is aware of limits of presented research. The one of limit is possible subjective teachers' perceptions of inspected methods and forms in the questionnaire. We could avoid the subjective teachers' perceptions in case of to be as a participant of the lessons and study teacher's teaching and also pupils' learning to examine real spectrum of methods and forms used by teachers.

In view of the above it could be possible identifications of lower representation of activating methods and forms in nowadays school science lessons.

Finally, it can be stated that the potential future research may be extended to other methods and forms, e.g. inquiry-based learning, problem-based learning or causal link between group learning and cooperative learning in groups.

CONCLUSION

Since the beginning of the 21th century the one of the key issues in education has been how to support pupils learning and develop the key competencies. The way could be using of a wide spectrum of appropriate methods and forms in the classes. Therefore the paper reports the results of the researches focus on the methods and forms used by Prague teachers supervising pedagogical training in science lessons, especially biology lessons. The results of the survey highlighted the fact that the teachers currently supervising pedagogical training from the rank of activating pupils' centred methods and forms integrate into the science biology lessons particularly project based learning, brainstorming and mind mapping more often than the teachers eight years ago. Educational methods and organizational forms are essential part of didactics process of teaching, therefore methods and forms should be reassess in the context of today's educational requirements.

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Contact address

RNDr. Jiřina Rajsiglová, Ph.D.

Department of Education and Didactics of Biology,
Faculty of Science, Charles University
Viničná 7, 128 43 Prague 2
e-mail: jirina.rajsiglova@natur.cuni.cz

VYUŽITÍ VRSTEVNICKÉHO VYUČOVÁNÍ PŘI REALIZACI ENVIRONMENTÁLNĚ ZAMĚŘENÉHO PROJEKTU

The use of peer teaching in the implementation of an environmentally-focused project

PAVLÁTOVÁ Věra

Abstract

The paper introduces the design, implementation and evaluation of the environmental program for pupils of primary school, which was created by the method of project teaching using the use of peer education. It was designed and created by pupils aged 8-17 for their classmates. Pupils gained information on sorting and waste prevention, recycling, vermicomposting, palm oil cultivation, or ocean acidification by other forms and methods than they used to. The project was implemented for 120 pupils aged between 7 and 12 years, using the questionnaire as the evaluation tool.

Key words

Environment, Peer Learning, Teaching

ÚVOD

Principem vrstevnického vyučování (peer education) je přirozené ztotožnění jedince s někým, kdo mu je blízký věkem, zájmy, sociálním zázemím či životním příběhem; kdo má schopnost ho v jeho názorech a postojích ovlivňovat.

Výhodou této formy vzdělávání ve škole je to, že spolu žáci mluví „stejným jazykem", efektivně a srozumitelně si učivo předávají. Proto často pochopí látku rychleji a žák, který má za úkol ji naučit ostatní nebo jim předat svou zkušenost, se s ní samozřejmě seznámí naprosto perfektně (Codlová, 2016). Dítě se vždy snadněji učí od jedinců s obdobnou asociační strukturou, jako má samo (Škoda, Doulík, 2011, s. 13).

V ČR se stejně jako v zahraničí využívá vrstevnického vzdělávání v peer programech k prevenci sociálně patologických jevů, ať to jsou programy s tematikou návykových látek (Nešpor, 2003; Ayaz, Açil, 2015), či sexuálního života a pohlavně přenosných chorob (Rydlo, 1995; Maas, Otte, 2009; Harold, 2011; Al-Iryani, 2013). V zahraničí se využívá s pozitivním efektem vrstevnického vzdělávání i v oblasti environmentální výchovy a udržitelného rozvoje (Arnold a kol. 2009; Carrico, Riemer, 2011; de Vreede a kol., 2014).

Na pozitivním efektu vrstevnického vzdělávání funguje i vize mezinárodního programu „Ekoškola“, kdy je na školách vytvořen Ekotým složený z žáků, učitelů i dalších zaměstnanců školy, který naplňuje metodiku "7 kroků Ekoškoly“ (Schneiderová a kol., 2012) a zaměřuje se zejména na lokální problémy udržitelného rozvoje, svou činností ovlivňuje ostatní vrstevníky, snižuje ekologický dopad školy a svého jednání na životní prostředí, zlepšuje prostředí ve škole i jejím okolí. Metodiku tohoto programu lze ve školách velmi efektivně využít při naplňování výstupů environmentální výchovy (NÚV, 2017).

Popisovaný projekt pro své spolužáky navrhlo, vytvořilo a realizovalo 18 žáků ve věku 8 – 17 let, kteří jsou aktivně zapojeni do programu Ekoškola, jsou zvyklí pracovat skupinově i projektově, diskutovat, bádat, prezentovat výsledky své práce, komunikovat s vedením školy i s městskou samosprávou. Zpočátku se žáci účastnili projektů umělých, či kombinovaných; krátkodobých, postupně již realizují projekty spontánní; střednědobé či dlouhodobé (Kratochvílová, 2009, s. 48; Coufalová, 2010, s. 10-11; Jezberová, 2011, s. 8), ve kterých používají i vrstevnické vyučování.

POPIS A METODIKA PROJEKTU

Žáky Ekotýmu velmi zaujal film „Zelená poušť“ (Gálik, 2012), diskutovali nad ním, starší vysvětlovali mladším některé nejasnosti. Poté žáky napadlo, že by mohli takto pohovořit o globálních problémech i s ostatními. Nejprve se žáci zamýšleli nad koncentrační ideou projektu (Kratochvílová, 2009, s. 43; Jezberová, 2011, s. 6), jako je např. téma, název, smysl, cíl a cílová skupina projektu. Rozhodli se tedy uspořádat v zeleném areálu školy pro spolužáky z 1. stupně ZŠ výchovně-vzdělávací zábavný environmentální program („EP“, heterogenní skupinky cca pěti žáků postupně projdou devět stanovišť), kdy na motivy známých pohádek vytvořili „Enviropohádky“ (spontánní, střednědobý, školní projekt).

Témata a náplň stanovišť byla vybrána metodami popsanými Sitnou (2009), jako je brainstorming, diskuse, pojmová mapa; za využití znalostí, knih, internetu, časopisů, konzultací s pedagogy. Zpracované informace ještě žáci reflektovali použitím metody Buzz Groups (Sitná, 2009, s. 76).

Postupně si žáci vytvořili harmonogram projektu včetně zodpovědné osoby za konkrétní krok, sepsali všechny potřebné pomůcky včetně rozpočtu, oslovili sponzory, vytvořili pracovní listy a cedule ke stanovištím, motivační letáčky, časový rozpis skupinek na stanovištích. Také vytvořili autoevaluační dotazníky obsahující otázky v podobě pocitových a postojových škál Likertova typu (Gavora, 2010; Chytrý, Kroufek, 2017), poté se žáci věnovali i publicitě projektu (v měsíčníku „Radnice“, na webu školy i na Žákovské ekologické konferenci v Mostě v dubnu 2017).

UKÁZKA ZPRACOVANÝCH STANOVIŠŤ PROJEKTU „ENVIROPOHÁDKY“

V tabulce 1. jsou uvedeny názvy stanovišť, probíraná témata a aktivity; pod tabulkou je ukázka jedné enviropohádky, otázky k diskusi na stanovišti a seznam potřebných pomůcek.

Tabulka 3 Stanoviště programu „Enviropohádky“, zdroj. žáci + autorka

	Názvy stanovišť	Probíraná témata	Aktivity pro žáky
1.	**O žížale Julii z vermikompostéru**	bioodpad, humus, hnojivo, vermikompostování, žížalí čaj, likvidace přebytků ze svačin ve školách	kreslení a modelování žížal, prohlídka vermikompostéru, žížaly, potrava pro žížaly (co smí a nesmí)
2.	**Jak krtek k recykalhotkám přišel**	recyklace, ukázka a prohlídka recyklomateriálů (např. flees)	výroba recyklohračky (želvičky), recyklační kufřík
3.	**Ozón nad zlato?**	ochrana před UV zářením, problematika přízemního ozónu	modelace molekuly ozónu, hry s bublinami
4.	**O živé, mrtvé a kyselé vodě aneb kam zmizel SpongeBob?**	úbytek korálů a živočišných hub díky okyselování oceánů CO_2	ukázka korálů a hub, pokusy s octem a slabými lasturkami či skořápkami
5.	**O Popelce ze sběrny**	vlastnosti kovů (hustota, vodivost), třídění, recyklace, výroba recyklovaných šperků	porovnání hmotnosti stejně velkých plíšků, jednoduchý obvod s voltmetrem, přesmyčky (hledání kovů)
6.	**O Slunečníkovi, Vodníkovi a Větrníkovi**	alternativní zdroje energie	hračky a roboti na solární pohon, výroba větrníčku
7.	**Tarzan proti palmě olejné**	problematika pěstování palmy olejné	výrobky s palmovým olejem a bez něho, „opičí dráha“
8.	**Sněhurka a sedm kontejnerů**	třídění odpadu a snaha o jeho minimalizaci	„běh s odpadem“, vyrobené pexeso, spojovačky, pyramidy z víček
9.	**Maková panenka a drogoví dealeři**	problematika drog	opium – vysvětlení, pohybové aktivity

O žížale Julii z vermikompostéru

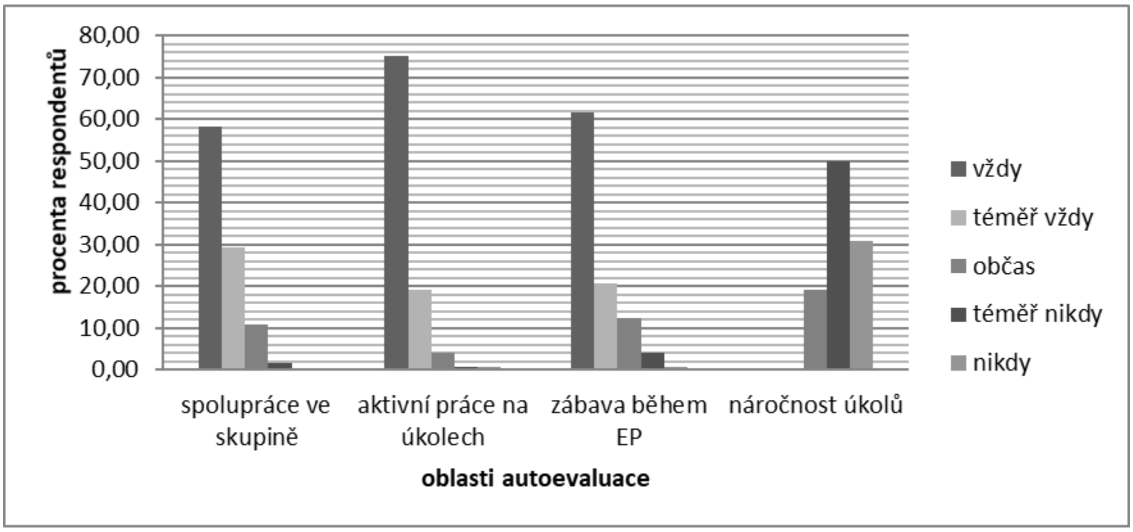
„Žížala Julie byla velmi mlsná. Nechtělo se jí cpát se jenom hlínou, která se v jejím dlouhém těle mění na humus. Bylo jí ukradené, že je díky tomu užitečná, v noci se jí zdálo o červených jablíčkách, žlutých hruškách a zelených okurkách, až si z toho snu vždycky poslintala polštář. Jednou slyšela vyprávět tetu Bětu o nějakém domečku, kde žížaly žijí a tyto dobroty dostávají od dětí. Jé, tam by se jí líbilo, hned se vydala domeček hledat...“

Diskuse: Jak se takový domeček jmenuje? Kde by ho Julie našla? Proč tam žížaly bydlí? Čím je krmíme a čím je krmit nesmíme? Čemu říkáme bioodpad? Proč jsou žížaly užitečné? K čemu potřebujeme hnojivo? Jak vzniká žížalí čaj? Můžeme mít vermikompostér i ve škole a doma? Jak se o něj starat? Co se ti na vermikompostéru líbí a nelíbí?

Pomůcky: vermikompostér, obrázky a ukázky, co se smí a nesmí dávat těmto speciálním žížalám – pracovní listy, živé žížaly, modelína na výrobu vlastních žížal, pastelky, fixy a papír na kreslení žížal, těstoviny (penne) a provázek – žáci navlékají co nejdelší žížalu.

VÝSLEDKY A DISKUSE

Kvalita projektu se měří jeho přínosem pro skupinu žáků i jednotlivce, jejich rozvojem v kognitivní oblasti, ale i rozvojem sociálních schopností a dovedností, umožní poznat žáky v nových situacích (Coufalová, 2006, s. 20). Vyhodnocení autoevaluačních dotazníků ukázalo (obrázek 1), že 87,5 % ze 120 respondentů pozitivně ocenilo spolupráci (součet kategorií „vždy“ a „téměř vždy“), 94,17 % aktivně pracovalo (stejný princip součtu kategorií), pro 82,5 % to byla zábava (stejný princip součtu kategorií), pro 19,17 % byly úkoly občas náročné.



Obr.1 Vyhodnocení evaluačních dotazníků, zdroj: žáci + autorka

Přínosem tohoto projektu byla i následná aktivita žáků – žáci 1. stupně začali vermikompostovat, v současné době jsou na škole využívány 4 vermikompostéry, na toto téma proběhly z iniciativy žáků i další vzdělávací akce pro rodiče, učitele i žáky z jiných škol. Nejzajímavějšími stanovišti byla žáky vyhodnocena č. 8 (Sněhurka…) a č. 9 (Maková panenka…) - žáci kreslili emotikon jen ke stanovišti, které bylo podle nich nejlepší.

Dalším zajímavým přínosem byl fakt, že jeden z účastníků projektu navrhl uspořádat ve škole besedy programů Green Life a Blue Life, ze kterých se vyvinula zajímavá a dlouhodobá spolupráce s panem Milanem Jeglíkem. Spolupráce spočívá mimo jiné také ve finanční podpoře, kdy se vybrané finance od žáků a učitelů školy použijí na záchranu deštného pralesa a na koupi a provoz fotopastí. Fotopasti jsou součástí programu „Oko tygra“, jehož úkolem je dle M. Jeglíka (zdroj – beseda s ním) získávání důkazů o existenci ohrožených druhů zvířat za účelem jejich ochrany a odhalování ilegálních aktivit pytláctví a dřevorubectví.

ZÁVĚR

Tento projekt byl postaven tak, jak vnímali projekt již představitelé reformní pedagogiky; jako komplexní úkol, podnik žákův, za jehož výsledky převzal žák odpovědnost, koncentrovaný kolem určité ideje, který obsahuje více problémů, má svůj cíl i uspokojivé zakončení (Žanta, 1934; Příhoda, 1936; Vrána, 1938). Pozici žáka v projektu, jež by měla být zásadní, zdůrazňují například také Rusek a Dlabola (2013).

Žáci – realizátoři projektu získali další zajímavé dovednosti a kompetence (NÚV, 2017) a zjistili, že nemohou podceňovat závěrečnou reflexi projektu, neboť přispívá k výměně zkušeností a poznatků, zachycení nálad, postojů, názorů, prožitků a postřehů všech účastníků, k získání zpětné vazby a poučení pro příští projekty, ale také ke zlepšení sociálního klimatu, jež je nezbytnou podmínkou úspěšné realizace projektů (Kratochvílová, 2009, s. 20).

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Contact address

Mgr. Věra Pavlátová

Katedra preprimárního & primárního vzdělávání
Pedagogická fakulta,
Univerzita J. E. Purkyně
Hoření 3083/13
400 11 Ústí nad Labem
e-mail: verapavlatova@seznam.cz; pavlatovavera@gmail.com

VÝUKA DĚJIN VĚDY: ZKUŠENOSTI ŽÁKŮ A UČITELŮ

History of Science at School: Pupils´ and Teachers´ Experience

POUPOVÁ Jana

Abstract

The article describes teachers´ experience with a project dealing with life and work of famous scientists: Pupils create a medial product (video, radio broadcast, cartoon…) presenting an important biologist, chemist or phycisist in his or her native language. The article describes also a study which monitored pupils´ view of the role of history of science at school and their experience with it. Its results show that pupils are aware of benefits of learning history of science though their experiences with this topic are quite limited.

Key words

History of science, project based learning, scientific literacy

ÚVOD

Významnou miskoncepcí, rozšířenou mezi žáky i veřejností, je představa, že existuje absolutní pravda, kterou věda pomáhá odhalit (Horner, Rubba, 1978). Jde o omyl, který je bohužel přiživován způsobem prezentace vědy ve školách. V nich se obvykle učí jen „hotové“ poznatky, díky čemuž věda působí jako soustava neměnných závěrů (Schwab, 1962; Horner, Rubba, 1978).

Proti tomuto způsobu výuky brojil již v 60. letech 20. století J. Schwab (1962), který se snažil vědu předvést jako nikdy nekončící hledání výstižného (nikoli ale definitivně prokázaného) popisu světa kolem nás (DeBoer, 2014). Ukázat vědu v tomto světle pomáhají její dějiny (Heilbron, 1999), které se místo výsledků vědeckého bádání soustřeďují na cestu, kterou se soudobého vědění dosáhlo. Nejen z tohoto důvodu začaly dějiny vědy v posledních dvaceti letech pronikat do kurikul mnoha evropských zemí (Dibattista, Morgese, 2014). Podle zprávy Eurydice dějinám vědy věnuje pozornost školství v Estonsku, Finsku, Lucembursku, Portugalsku nebo Rakousku, v Česku nikoliv (EACEA, 2011).

Pokud by chtěl učitel přírodovědných předmětů dějiny do své výuky začlenit, stojí před otázkou, jak na to. V minulosti se uplatnily především následující způsoby: rozbor případových studií, čtení původních vědeckých texů (s následnou diskusí nad nimi) a studium životopisů významných vědců, ať již v podobě četby či sledování filmu s touto tématikou (McComas, 2014).

Tento příspěvek ukazuje, jak dějiny vědy pojmout formou životopisně zaměřené projektové výuky. Článek přibližuje průběh projektu, pohled zúčastněných učitelů na něj a také výsledky výzkumu mapujícího osobní zkušenosti žáků s výukou dějin vědy i jejich názory na ni.

PŘÍRODOVĚDCI MINULOSTI I SOUČASNOSTI – TÉMA PRO PROJEKT

Na čtyřletém pražském gymnáziu byl opakovaně realizován projekt zaměřený na významné přírodovědce. Cílem projektu bylo vytvořit mediální produkt (film – hraný či animovaný, webové stránky, blog, plakát, komiks, fotoreportáž, rozhlasovou relaci, noviny nebo časopis), který představí život a dílo zvolené osobnosti vědeckého světa. Produkt vytvářely vždy čtveřice žáků maturitního ročníku v průběhu dvou po sobě jedoucích školních dnů na začátku září. Po uplynutí projektových dnů mohli studenti během dalšího týdne dokončit práci doma. Mediální produkt byl vytvářen v rodném jazyce zvolené osobnosti, přičemž žáci byli do pracovních skupin vylosováni s ohledem na jimi zvolený jazyk. (Výběr byl limitovaný spektrem vyučovaných cizích jazyků, tj. jednalo se buď o angličtinu, němčinu, nebo francouzštinu.) Hotový mediální produkt byl v příslušném jazyce prezentován ostatním žákům ročníku na předmaturitním soustředění, které se konalo v polovině září. Při prezentaci musel pohovořit každý člen skupiny. Žáci při ní zdůvodňovali volbu osobnosti, popisovali průběh své práce a hodnotili její výsledek. Za své vystoupení dostali od učitelů cizích jazyků známku, do které se kromě jazykových dovedností promítala i spolupráce ve skupině.

Popsaný projekt splňuje typické rysy projektu tak, jak je formuluje Bell (2010): Má interdisciplinární charakter, poskytuje žákům prostor pro kreativitu, podporuje spolupráci v týmu i rozvoj jazykových dovedností a jeho výsledek je veřejně prezentován.

METODIKA

Mezi žáky výše uvedeného čtyřletého gymnázia proběhlo dotazníkové šetření, jehož cílem bylo zjistit dosavadní zkušenost žáků s výukou dějin vědy a jejich názory na ni. Dotazníkové šetření proběhlo v září 2017 a zúčastnilo se ho 89 žáků prvního ročníku (ve věku 15 let), které v budoucnu výše popsaný projekt čeká. (Provádět tento výzkum ve vyšších ročnících nebylo vhodné, protože někteří z těchto žáků během svého studia absolvovali volitelný seminář z dějin vědy. Jejich odpovědi by výsledky výzkumu zkreslily.) V dotazníku byly položeny otevřené i uzavřené otázky, jejichž plné znění je uvedeno v příloze. U otázek s volbou odpovědí bylo zjišťováno procentuální zastoupení jednotlivých odpovědí. Vyhodnocování ostatních odpovědí probíhalo formou otevřeného kódování.

Dotazníkové šetření bylo použito i pro zhodnocení přínosu výše popsaného projektu. Reflexe silných a slabých stránek projektu se zúčastnili čtyři vyučující (dva vyučující angličtiny, jeden francouzštiny a jeden němčiny) realizující tento projekt v září 2017. Byly jim položeny následující otázky:

1. V čem podle vás spočíval hlavní přínos jazykově-mediálního projektu zaměřeného na významné přírodovědce?
2. Osvědčily se některé osobnosti více (tj. byly u nich nápadně kvalitnější mediální produkty), nebo byla kvalita produktu závislá spíš na šikovnosti konkrétní skupiny?
3. Uvítali byste nějaké změny ve vlastním průběhu projektu (jeho organizaci, způsobu hodnocení apod.)? Pokud ano, jaké?
4. Co bylo na základě vašich zkušeností pro studenty na projektu nejtěžší?
5. Jaké byly nejčastější nedostatky v mediálních produktech?
6. Co bylo na projektu obtížné pro vás?

VÝSLEDKY

Hodnocení projektu učiteli

Za hlavní přínos projektu považovali všichni dotazovaní učitelé zlepšení mluveného projevu žáků a seznámení s životem zajímavé osobnosti. Tři z nich dále považovali za důležité zlepšení schopnosti žáků spolupracovat. Podle všech vyučujících závisela kvalita mediálního produktu především na kreativitě konkrétní skupiny. Dva z učitelů nicméně upozornili, že když byl osobní život zvoleného vědce opravdu zajímavý (jako v případě S. Hawkinga), vznikaly kvalitnější produkty. Při opakovaných realizacích projektu učitelé měnili způsob hodnocení (kdo hodnotil, co i jak) a pravidla pro rozdělování žáků do skupin. Za nejobtížnější pro žáky považovali učitelé tvorbu cizojazyčného textu a prezentaci mediálního produktu (tuto odpověď uvedli tři učitelé), na druhém místě pak zvládnutí spolupráce ve skupině (tuto odpověď uvedli dva učitelé). Učitelé žákům nejčastěji vytýkali nedodržení termínu odevzdání produktu, resp. nesplnění časového limitu prezentace, a nedostatečnou jazykovou kvalitu produktu (tato odpověď se vyskytla třikrát). Všichni učitelé se shodli, že pro ně samotné bylo nejtěžší nastavit přijatelný způsob hodnocení projektu.

Zkušenosti žáků s výukou dějin vědy

Celkem 90 % žáků uvedlo, že se s dějinami vědy ve škole setkali, a to nejčastěji ve fyzice, chemii a přírodopisu (tab. 1).

Tab. 1 Ve kterých přírodovědných předmětech jste se s dějinami věd setkali?

chemie	přírodopis	zeměpis	fyzika	matematika
54%	51%	29%	64%	19%

Drtivá většina žáků uvedla, že se dějinám věnovali jen málo (tab. 2).

Tab. 2 V jaké míře jste se v těchto předmětech dějinám věd věnovali?

hodně	průměrně	málo	nevím
0%	11%	82,50%	6,50%

Téměř tři čtvrtiny žáků uvedly, že bylo obvykle uvedeno pouze jméno vědce či objevitele (tab. 3).

Tab. 3 O jaký typ informací šlo nejčastěji?

jméno vědce	72%
informace o jeho životě	4%
stručný popis objevu	20%
bližší informace o objevu	4%

Dějiny byly nejčastěji připomínány v souvislosti s terminologií, v necelé polovině případů šlo o jinou odbornou otázku (tab. 4).

Tab. 4 V jaké souvislosti jste se dějinám věd věnovali nejčastěji?

s odbornou otázkou	47%
s novou technologií	33%
s charakterem doby	16%
s terminologií	56%
v jiné souvislosti	0%

Zhruba tři čtvrtiny žáků uvedly, že šlo o součást výkladu učitele. V jiných situacích se žáci s dějinami věd setkávali méně často (tab. 5).

Tab. 5 Jakou formou jste se o dějinách věd učili? Můžete označit více odpovědí.

Šlo o součást výkladu učitele.	76%
Četli jsme knihu či jiný text.	15%
Zpracovávali jsme referát.	33%
Dívali jsme se na film.	23%
Jinak (pracovní sešit, domácí úkol)	2%

Třetina žáků se dějinám věd věnovala i v dějepise, a to nejčastěji v souvislosti s průmyslovou revolucí a oběma světovými válkami (tab. 6).

Tab. 6 Učili jste se o historii věd v dějepise?

ano	ne	nevím
32%	32%	36%

Názory žáků na výuku dějin vědy

Téměř polovinu žáků dějiny vědy spíše bavily (tab. 7). Zdůvodnění, proč tomu tak bylo, uváděli žáci jen výjimečně. Buď šlo o zalíbení v samotném tématu, nebo o radost z učení obecně.

Tab. 7 Bavily vás dějiny věd?

ano	spíše ano	spíše ne	ne	nevím
12%	43%	17%	4%	24%

Téměř polovina žáků považovala výuku dějin vědy spíše za smysluplnou, čtvrtina za vyloženě smysluplnou (tab. 8). Svůj názor nejčastěji opírali o argument, že znalost dějin vědy pomáhá lépe pochopit soudobý stav vědy. Druhý nejčastěji uváděný důvod byl názor, že jde o součást všeobecného vzdělání. Někteří žáci uvedli, že jim dějiny vědy pomáhaly při učení.

Negativně hodnotilo smysluplnost výuky dějin vědy malé procento žáků. Svůj názor zdůvodňovali tím, že je důležitější znát soudobý stav poznání a že jsou dějiny vědy nadstavbové učivo. Opakovaně byl jako argument uvedený nepřitažlivý způsob výuky tohoto tématu.

Tab. 8 Pokládáte za smysluplné věnovat se ve škole dějinám věd?

ano	spíše ano	spíše ne	ne	nevím
24%	46%	5%	1%	24%

Na otázku, zda žáky oslovil životní příběh nebo dílo některého vědce, odpovědělo kladně 41 % žáků. Nejvíce jich uvedlo M. Curie-Sklodowskou (6x) kvůli její houževnatosti, obětavosti vědě a schopnosti prosadit se v mužském světě. Druhou nejčastěji uváděnou osobností byl S. Hawking (3x), u něhož žáci poukazovali kromě pracovního nasazení na schopnost vyrovnat se s vlastním hendikepem. Na třetí místo se dostal A. Einstein (2x), s jehož životním stylem se někteří žáci ztotožňovali.

DISKUSE

Odpovědi na žákovský dotazník svědčí o tom, že se dějinám vědy v českých školách příliš pozornosti nevěnuje. Toto zjištění je v souladu se zprávou Eurydice (EACEA, 2011). Že jde o dlouhodobý stav, dokládá obdobný závěr Folty (1999) starý téměř 20 let.

Podle McComase (2014) seznámení s dějinami vědy zlepšuje pochopení učiva a také porozumění principům fungování vědy. Je potěšující konstatovat, že si žáci jsou (navzdory své omezené zkušenosti) tohoto přínosu vědomi: Vypovídají o tom žákovská zdůvodnění odpovědí na 9. otázku.

Dotazníkové šetření mezi učiteli vyzdvihlo jako jedno z hlavních pozitiv popisovaného projektu seznámení se zajímavou osobností. Již na počátku 20. století upozorňoval

F. Westaway na schopnost biografií zlidštit svět vědy a ukázat vědce jako následováníhodný vzor (Brock, Jenkins, 2014). Pravdivost tohoto názoru dokládají žákovská zdůvodnění odpovědí na 10. otázku: Sympaticky na žáky působily především ty příběhy, které velké vědce ukázaly jako „normální“ lidi, překonávající překážky a zažívající i neúspěchy.

Na druhou stranu Barth (1999) ze své osobní zkušenosti konstatuje, že životy slavných vědců nezapůsobí na všechny žáky: Nezanedbatelnou část nudí. Toto je v souladu se zhruba stejným (polovičním) zastoupením žáků, které nějaký vědec oslovil, resp. neoslovil. Tento výsledek by mohl souviset i s velkými rozdíly v kvalitě mezi mediálními produkty jednotlivých skupin, byť podle vyjádření učitelů na ni měly stěžejní vliv tvůrčí schopnosti žáků.

ZÁVĚR

Dotazníkové šetření zjišťující dosavadní zkušenost patnáctiletých žáků čtyřletého gymnázia s výukou dějin vědy ukázalo, že se této problematice na základních školách příliš pozornosti nevěnuje. Přesto si je většina žáků vědoma přínosu dějin vědy a potažmo smysluplnosti jejich výuky.

Článek také přiblížil méně obvyklý způsob, jak historické téma ve výuce pojmout. Jednalo se o projektové vyučování, jehož výsledkem byl cizojazyčný mediální produkt o významném přírodovědci. Dotazníkové šetření mezi zúčastněnými učiteli ukázalo, že jeho realizace byla náročná jak pro žáky (kvůli zvládnutí jazykové stránky věci), tak pro učitele (kvůli nesnázím s hodnocením výsledků projektu).

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Contact address

Mgr. Jana Poupová, Ph.D.

Katedra učitelství a didaktiky biologie
Přírodovědecká fakulta,
Univerzita Karlova
Viničná 7
128 00 Praha 2
e-mail: jana.poupova@natur.cuni.cz

VLIV VÝUKOVÉHO PROSTŘEDÍ NA OSVOJOVÁNÍ KOGNITIVNÍCH A AFEKTIVNÍCH CÍLŮ VÝUKY ŽÁKY NA PRIMÁRNÍM STUPNI ZÁKLADNÍCH ŠKOL

The influence of educational environment on acquiring cognitive and affective goals of teaching pupils at primary schools

VÁCHA Zbyněk

Abstract

This paper is focused on impact of educational environment on achieving mainly affective goals. 137 primary school pupils were participated on the research. Education was focused on topic: The freshwater animals and surroundings. Data was collected during pair groups experiment. Education in the experimental group was situated on the school garden. Pupils in the control group were taught in a classroom. The visible difference between these two groups was evident mainly in the affective goals. Pupils in the experimental group had bigger interest on education that pupils in the control group.

Key words

Primary school, science and environment, cognitive and affective skills, pupil interest

ÚVOD

Je otázkou každého pedagoga jaké vyučovací metody, formy a prostředí pro výuku zvolí. Společné působení těchto faktorů pak může mít výrazně rozdílný vliv na proces osvojování si nových znalostí žáky, ale i na celkovou oblíbenost školního vyučování. Jednotlivé výukové metody a formy či nejrůznější výuková prostředí mohou mít odlišný účinek na rozvoj kognitivního, afektivního či psychomotorického vývoje žáka. K uvedené problematice byl designován výzkum, který měl za úkol zjistit efektivitu odlišného výukového prostředí na dosahování kognitivních a afektivních cílů v hodinách přírodovědy na primárním stupni základních škol.

GENERACE Z A ALFA

Ve společnosti se stále více projevuje trend odcizování člověka přírodě (Abram, 2013). Negativní vliv na tuto skutečnost má charakter dnešní doby, kterou můžeme považovat za přetechnizovanou (Jančaříková, 2016). Výrazné rozdíly ve vztahu k přírodě jsou patrné mezi jednotlivými generacemi.

Pro sociologické výzkumy ve Spojených státech amerických je typické označování jednotlivých generací písmeny. Pojmenování těchto generací jsou pak přenášena i do ostatních částí světa (Papáček, 2010). V rámci příspěvku budou vysvětleny generace Z a alfa, jelikož mají věkově nejblíže ke sledované skupině žáků ve výzkumné části. Generace Z je označení pro lidi narozené mezi roky 1990 a 2000 (Jančaříková, 2016). V České republice však tato generace nastoupila se zpožděním, jak uvádí např. Papáček (2010). Jedná se o generaci, která se narodila v době plně nasycené informačními technologiemi a internetem, upřednostňující elektroniku před knihou (Posnick-Goodwin, 2010).

Do generace alfa patří lidé, kteří se narodili po roce 2010 rodičům, již plně využívajícím výpočetní techniku. Jejich vazba na digitální prostředí je a bude výrazná. Dokonce ještě silnější než u generace Z (Jančaříková, 2016).

Z výzkumných šetření vyplývá (např. Čížková, 2013), že v závislosti na výše uvedeném dochází k postupné ztrátě zájmu žáků o přírodní vědy a přírodu celkově. K poklesu zájmu dochází již v průběhu základní školní docházky a viditelně narůstá s věkem žáků (Gafoor, 2011; Eilks a kol., 2004). Do budoucna tak bude na učitelích přírodovědných předmětů, aby se tomuto trendu postavili a pokusili se u žáků již v raných ročnících školní docházky posilovat vztah k přírodě (Vácha, Ditrich, 2016). Nebude to úkol snadný, ale určitě ne nesplnitelný.

VÝUKA V PROSTŘEDÍ ŠKOLNÍCH ZAHRAD

Mimotřídní výuka má značný potenciál u žáků podnítit vztah k přírodě (Vácha, Petr, 2013). Jako jedno z nejvhodnějších prostředí pro výuku v terénu v blízkosti školy můžeme považovat prostory školních zahrad (Vácha, 2015; Graham a kol., 2005). Výuka na školní zahradě může žákům přiblížit prostředí, ve kterém žijí (Smith, 2002), umožnit navštěvovat živou laboratoř podporující implikaci badatelských aktivit (Smith, Motsenbocker, 2005), podporovat interdisciplinaritu ve výuce (Sobel, 2005) či osvětlovat principy udržitelného rozvoje (Castagino, 2005).

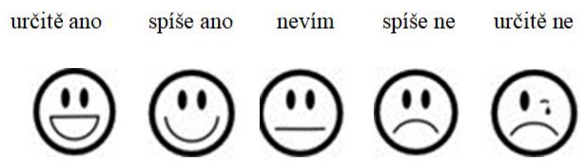
METODIKA

Na výzkumu participovali žáci šesti čtvrtých tříd primárního stupně ze třech základních škol. Konečný výzkumný vzorek byl tvořen 137 žáky - 75 dívkami a 62 chlapci.

Téma Přírodní společenstva: Živočichové sladkovodních ekosystémů a okolí bylo vyučováno na každé z participujících škol ve dvou stejnoměrně rozdělených skupinách (viz níže) za využití odlišného výukového prostředí.

Data, zjišťující dosažení kognitivních cílů, byla získávána na základě metody experimentu typu spárovaných skupin (např. dle Mittenecker, 1968; Chráska, 2007). Před zahájením experimentu byl žákům zadán test vstupních znalostí (pretest) v tematické oblasti: živočichové sladkovodních ekosystémů a okolí, který obsahoval deset otázek, a žáci v něm mohli získat maximálně 10 bodů. Na základě výsledků tohoto měření došlo k vytvoření dvou skupin na každé participující základní škole (spárované výběry), v nichž bylo homogenní rozdělení žáků dle úspěšnosti v pretestu - žáci se stejným počtem dosažených bodů byli do skupin rozdělováni náhodně. V jedné z těchto skupin na každé participující škole pak probíhala výuka v prostředí školní zahrady Pedagogické fakulty Jihočeské univerzity (tzv. experimentální skupina - celkem 69 žáků). Ve druhé skupině byli žáci vyučováni v budově školy v tradiční třídě (tzv. skupina kontrolní - celkem 68). Výuková jednotka trvala v experimentální i kontrolní skupině shodně 90 minut a vyučoval jí stejný učitel (autor příspěvku). V obou skupinách byla využívána především metoda přímého a nepřímého pozorování přírodnin (v závislosti na místě výuky). Týden po ukončení výuky, došlo u žáků k ověření výstupních znalostí prostřednictvím jednotného posttestu a na základě jeho výsledků byla porovnaná výkonnost kontrolní a experimentální skupiny.

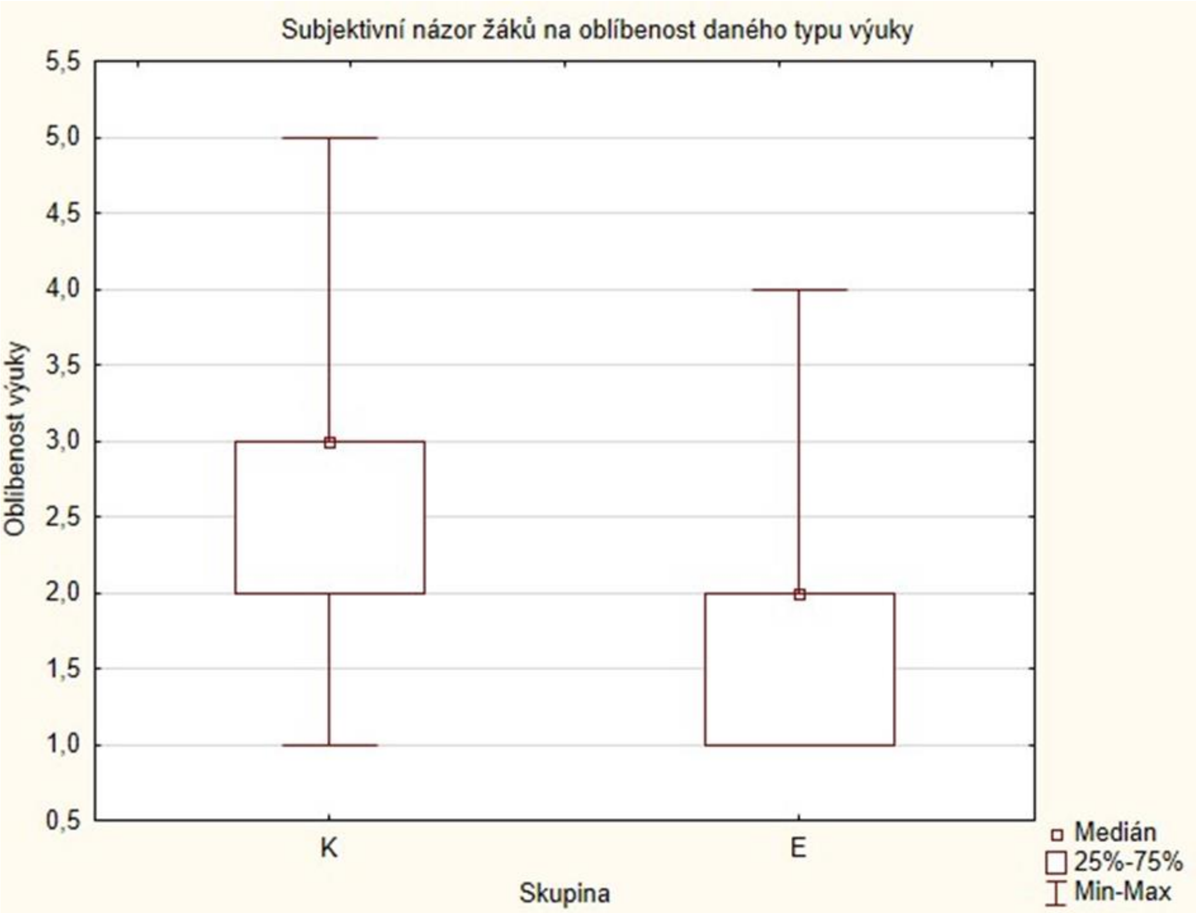
Pro ověření dosažení afektivního cíle, který zjišťoval zájem žáků o dané téma, byl využit pětistupňový dotazník Likertova typu uzpůsobený věku a možnostem žáků primárního stupně základních škol (např. dle Reynolds Keefer a kol., 2009). Dotazník obsahoval dvě položky (1) Dnešní výuka mě bavila a (2) Podobný typ výuky bych v daném výukovém prostředí do vyučování zařadil častěji (opakovaně). Žáci měli za úkol vybarvit emotikon odpovídající jejich názoru (viz obrázek 1).



Obr. 1 Škála dotazníku Likertova typu pro žáky na primárním stupni základních škol, zdroj vlastní

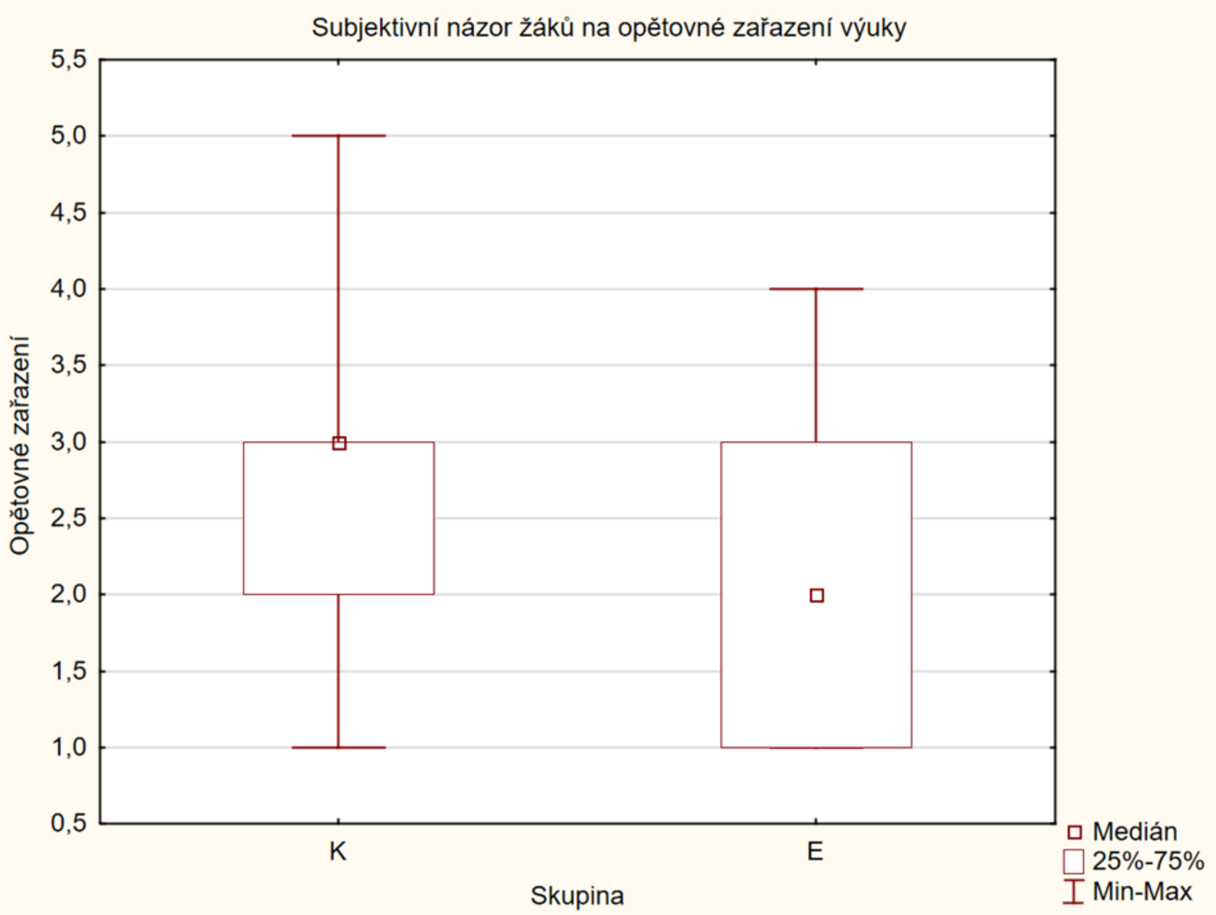
VÝSLEDKY

Hlavním cílem výzkumu bylo otestovat především vliv výukového prostředí na dosahování afektivních (hodnotových) cílů. První otázka zjišťovala žákův subjektivní názor na skutečnost, zdali ho absolvovaná výuka bavila. Obrázek 2 poukazuje na vysoce statisticky průkazné rozdíly mezi experimentální a kontrolní skupinou, tedy skupinou vyučovanou v prostředí školních zahrad (experimentální - E) a skupinou absolvující výuku v běžné třídě (kontrolní – K). Žáci v experimentální skupině vykazovali mnohem větší zájem o výuku než žáci v kontrolní skupině. Položka byla analyzována na základě Mann-Whitney testu (t = 5.84; p < 10-7).



Obr. 2 Subjektivní názor žáků na oblíbenost výuky, zdroj vlastní

Druhá otázka, obsahově zaměřená na dosahování hodnotových cílů u žáků, zjišťovala žákův subjektivní názor na skutečnost, zdali by podobný typ výuky v daném výukovém prostředí zařadil do výuky častěji (opakovaně). Obrázek 3 znázorňuje staticky významné rozdíly mezi názory žáků kontrolní a experimentální skupiny. Žáci v experimentální skupině, která probíhala v prostorách školní zahrady, se vyjadřovali výrazně pozitivněji pro opětovné zařazení podobného typu výuky v uvedeném prostředí oproti žákům ve skupině kontrolní. Položka byla analyzována na základě Mann-Whitney testu (t = 4.67; p < 10-5).



Obr. 3 Subjektivní názor žáků na opětovné zařazení výuky, zdroj vlastní

Systém pretest – posttest, který měl za cíl ověřit dosažení kognitivních cílů (úroveň znalostí v dané tematice) u žáků v kontrolní a experimentální skupině na žádné statisticky významné rozdíly nepoukázal. U obou skupin došlo k téměř totožnému navýšení průměrných bodových skórů mezi pretestem a posttestem (viz tabulka 1). Neprokázal se tak žádný signifikantní vliv výukového prostředí na proces osvojování nových vědomostí u žáků na primárním stupni základních škol.

Tab. 1 Průměrné bodové hodnoty dosažené žáky v jednotlivých testech, zdroj vlastní

Pretest K	Posttest K	Rozdíl	Pretest E	Posttest E	Rozdíl
3,5	7,75	4,25	3,5	7,50	4

K= kontrolní skupina, E = experimentální skupina

ZÁVĚR

Z výsledků výzkumného šetření je patrné, že občasná změna stereotypního prostředí běžné třídy za jiné výukové prostory (v tomto případě školní zahradu) může mít pozitivní vliv na zájem žáků o vyučování. Žáci v experimentální skupině projevovali statisticky významně větší zájem o výuku a chtěli by podobný typ vyučování do prostředí školních zahrad implikovat opakovaně. Do budoucna by výuka ve venkovním prostředí mohla být jedním z faktorů, který pozitivně ovlivní žákovské vnímání přírodních věd a podpoří v nich zájem o přírodu vůbec. Je však nutné, aby byla výuka ve venkovním prostředí zařazována do vzdělávacího procesu již v předškolním vzdělávání a na primárním stupni základních škol, kdy se formuje žákova osobnost.

Pozitivní ani negativní vliv výukového prostředí na dosahování kognitivních cílů prokázán nebyl. Přesto je však reálné, že by při opakovaném testování stoupala znalostní úroveň u žáků, pro které bude vyučování zábavnější. Zábavnost výuky by mohla pozitivně ovlivnit jejich vnitřní motivaci. Je jasné, že výzkumné šetření mohlo být zkresleno i celou řadou dalších faktorů (v rozdílném prostředí nelze použít úplně stejné výukové metody, různý počet žáků v jednotlivých třídách, odlišné materiální vybavení), a výsledky tak nemůžeme generalizovat, ale mohlo by sloužit jako pilotní průzkum pro další mnohem rozsáhlejší výzkumný záměr.

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Contact address

Mgr. Zbyněk Vácha, Ph.D.

Katedra biologie
Pedagogická fakulta,
Jihočeská univerzita
Jeronýmova 10
371 15 České Budějovice
e-mail: zvacha@pf.jcu.cz

TEMPERATURE AND ENVIRONMENTAL PHYSICS

ŠVECOVÁ Libuše

Abstract

In the article we present the results of a questionnaire given to 60 pupils of secondary schools, the goal of which was to determine their views on climate change and global warming in the context of physics. Because the results have shown that pupils consider temperature in the context of physics, climate change and global warming, an educational project has been proposed, designated Temperature and Climate change.

Key words

Environment, primary school, project-based learning, social media, society and environment education.

INTRODUCTION

The concept of environmental physics is not included in any Framework Educational Programmes in the Czech Republic. The concept, however, is currently undergoing rapid development as a result of climate change and global warming.

Lepil *et al.* (2009, pp. 7) provides this definition of environmental physics: "It is a field that aims to point out the importance of physical factors for the existence of mankind and living organisms in the environment, but also to warn him against introducing physical knowledge into practice through technical applications without due consideration. In this way he develops his thinking to focus on the environment. It is not just about the physics of the environment, but the spirit of the concept of sustainable development."

We will present some of the terms that pupils of primary school will encounter in the teaching of physics that are related to environmental physics: electromagnetic waves e.g. ultraviolet radiation; weather; greenhouse effect, measuring temperature; converting temperature measurements in degrees Celsius to different temperature scales; physically measuring the principle of the liquid thermometer and bi-metal thermometer, i.e. the thermal expansion of substances; heat exchange, change of state, heat engine, etc.

In the article we present the results of a questionnaire given to 60 pupils of secondary schools, the goal of which was to determine their views on climate change and global warming in the context of physics. Because the results have shown that pupils consider temperature in the context of physics, climate change and global warming, an educational project has been proposed, designated Temperature and Climate change. The aim of this project is to show a link between increasing average global temperatures and the consequences of it for life on Earth.

At present, the project-based learning has begun to be used in the teaching of natural sciences (Ješková, Lukáč, Hančová, Šnajder, Guniš, Balogová, Kireš, 2016; Balogová, Ješková, Hančová, Kireš, 2017; Doorman, Jonker, Wijers, Suk, Bílek, Machková, 2016; Trna, Trnová, 2015; Prášilová, 2017, pp. 123-130). We consider this scientific form of teaching to be interesting for pupils and it may be applied in the form of a Science Day held around the date of Earth Day.

Samples of projects dealing with physics and environmental education are given in the following publications (Švecová, 2017, pp. 279-284; Švecová, Fanta, Nemčik, 2017, pp. 309-312; Olšovský, 2010).

MATERIALS AND METHODS

A research of selected concepts of environmental physics that do not form a part of Framework Educational Programmes within the Czech Republic was undertaken by e.g. (Švecová & Mechlová, 2014; Švecová 2015, Švecová, 2016). Švecová & Mechlová (2014) state the following:

1. A research conducted in the spring of 2006 in respect of 69 pupils of the 8th and 9th grade of elementary school and 100 pupils of 2nd grade of secondary school showed that pupils regard the concepts ´cyclical´ and ´reversible action´ to be identical.

2. A research conducted in the spring of 2013 in respect of 35 university students of the 1st year and at the end of the autumn 2013 in respect of 75 university students of the 1st year served to confirm this result. Another material finding was that in the spring, 43% and in the autumn 51% of questioned university students considered climate changes which we observe on Earth to be reversible. It follows from both studies that pupils of primary and secondary schools as well as university students consider reversible action to be identical to a cyclical one, i.e. that preconceptions of pupils in respect of reversible action do not depend on the phase of their education, which can lead to incorrect understanding of changes which take place on Earth.

Švecová (2016) summarises the reasons why conceptions reversible and irreversible processes are relevant for physics and for concept of environmental education. Švecová (2016) points out that the media uses terms from physics in connection with climate changes, but at primary school and secondary schools the pupils do not come across the specified terms in physics lessons, and their incorrect interpretation could lead to an unsuitable attitude towards climate changes and global warming.

The opinions and knowledge of pupils in the Czech Republic concerning climate changes and global warming have been dealt with by, for example (Skalík, 2015; Miléř, Sládek, 2011; Švecová 2015).

Skalík (2015) published the results of a pilot study dealing with the attitudes of Czech adolescents towards climate changes in relation to information sources that they trust. Skalik (2015) states “The main focus of the study is thus to offer a segmentation of youth in the issue of climate change related to information sources they trust and also related to the type of information on climate change”

Climate literacy in the Czech Republic has been dealt with by, for example (Miléř, Sládek 2011, pp. 150), who states "We designed a three year course for upper primary school in order to improve the climate literacy of the population. We have performed a three year testing of the improved curriculum at the pilot upper primary school. The curriculum was designed for grades 7 to 9 of the Czech educational system.”

Although in the Czech Republic studies were carried out and published dealing with climate change and global warming in the context of education, no sufficient attention has yet been paid to research of concepts from the area of environmental physics.

On the basis of the published research, research was proposed aimed at ascertaining the opinions of Czech pupils towards climate changes and global warming, and whether pupils were aware of the linkage between knowledge from physics and climate changes after the end of primary school. The research was conducted in the form of a questionnaire survey in two phases. Initially 4 items were proposed. The items were open, in the form of controlled interviews. The controlled interviews were conducted with four pupils of the ninth grade at primary school in the spring of 2017, namely with 15-year old pupils. The aim of the interviews was to determine whether pupils understood the questions. The pupils were attending the final year of primary school and were selected at random. The length of the interview was 20 to 30 minutes. There were three girls and one boy included in the sample.

Based on the interview results, the questionnaire survey was expanded to include two other items. The questionnaire survey was carried out in the autumn of 2017 with pupils of the first year of secondary school, i.e. 15-year and 16-year old pupils. The aim of the survey was to find out what kind of opinion the pupils have on climate change and global warming and physics after their compulsory schooling, i.e. after the end of their primary school education. To determine terms that pupils would put in context with climate change and knowledge in physics which pupils gained at primary school and through the media. The questionnaire survey involved sixty pupils, a total of 38 girls and 22 boys. The questionnaire was anonymous and voluntary.

Questionnaire survey

The questionnaire consisted of a total of six open questions.

1. Are you interested in information about climate change and global warming?

2. Where have you seen information about climate change and global warming?

3. In which primary school subjects did you encounter information about climate change and global warming?

4. In which media have you encountered information about climate change and global warming?

5. Can you give us an example of how physics relates to global warming and climate change?

6. Can you give us examples of climate change and the global warming of the Earth?

The results of the questionnaire survey showed that 45 % of the pupils said that they were interested in information about climate change and global warming; 31% of the surveyed pupils said they were not interested in information about climate change and global warming; 24 % of the surveyed pupils replied, “I don’t know”, or did not respond to the question.

For the second item, the pupils stated where they encountered information about climate change and global warming A total of 48 % of the surveyed pupils said that they encountered information about climate change and global warming in the media; 40 % of the surveyed pupils indicated that they encountered the information in school; 12 % of the surveyed pupils failed to respond to the question, or provided a different response.

For the third item, the pupils were supposed to tell us the primary school subjects where they encountered information about climate change and global warming A total of 34% of the pupils said that they encountered information on climate change and global warming in primary school in natural history; 12 % of the surveyed pupils encountered the information in primary school in geography; 24 % of pupils provided a different answer, i.e. Earth Day; 30 % of the surveyed pupils failed to provide a response.

For the fourth item, the pupils were supposed to tell us in which media they encountered information about climate change and global warming The fourth item was answered by the pupils as follows: a total of 34 % of the surveyed pupils said the Internet; 24 % of pupils television; 3 % of pupils the radio; 39 % of pupils provided a different response, or failed to provide any response.

For the fifth item, the pupils were supposed to give us an example of how physics relates to global warming and climate change. A total of 36 % of the surveyed pupils said, “We measure the temperature”, 21 % said renewable energy sources, 8 % of pupils the greenhouse effect, while 40 % of the surveyed pupils failed to respond to the question, or provided another response.

For the sixth item, the pupils were supposed to give us an example of climate change and the global warming of the Earth. A total of 39% of pupils stated the greenhouse effect; 23 % air pollution; 13% of pupils reported the increasing temperature of the Earth; 11 % said the ozone hole; 14 % of pupils failed to respond to this item.

The results show that 36 % of the surveyed pupils said temperature was connected to physics and climate change and global warming. Based on these results, an educational project was created designated Temperature and Climate change. Since 34 % of the surveyed pupils responded that they have encountered information on climate change and global warming in primary school in the subject of natural history, the teacher will have the role of consultant within this proposed project.

DISCUSSION

The aim of the implemented research was to ascertain the opinions of Czech pupils towards climate changes and global warming, and whether pupils were aware of the linkage between knowledge from physics and climate changes after the end of compulsory school attendance. To determine terms which pupils put in context with climate change and knowledge in physics.

The research was carried out in the form of a questionnaire survey in a non-representative sample of 60 secondary-school pupils. The results showed that pupils primarily associate climate changes with rising global temperature.

The results also confirmed the results of other research. Skalík (2015) states "A sample of students from Masaryk University and several grammar schools from Czech Republic participated in the quantitative study focusing on their knowledge of climate change, information sources they use and proenvironmental attitudes. The survey highlighted the extremely low level of students' knowledge."

Skalík (2015) implemented research in respect of secondary-school pupils as well as university students. The students received a questionnaire which stated terms chosen by the author of the article and the respondents selected a correct answer from the choice of 4 responses. In our research we focused on pupils after completion of compulsory schooling; the pupils formulated the answers themselves. The research has shown that pupils stated only 3 terms related to climate change and knowledge in physics which they acquired at primary school: temperature, renewable energy sources and the greenhouse effect. These terms are stated in textbooks on physics designated for elementary schools, or pupils encountered them in the media.

Opponents of including environmental physics in lessons may submit their objections. Information on climate change changes rapidly. The attitude of scientists concerning climate change and global warming greatly differ. How are teachers supposed to navigate such a situation since they do not have the opportunity nor time to study scientific articles?

We are presenting a proposal on how to make it possible to include physical environmental problems in the teaching of physics. While resolving the problem of environmental physics, pupils should build on the knowledge they have acquired during the teaching of all natural science subjects. Concepts and physical relationships may be explained on the basis of real experiments. Due to the fact that the approach of scientists to climate change and global warming greatly differ, it should be up to the pupils to decide for themselves whether the changes are occurring or not. This may only be achieved if we familiarize pupils with the data provided and updated by scientific organizations. Most of the data is provided in the form of graphs and interactive animations. This will help pupils develop the ability to "read from a graph" in order to deal with the causes and effects of the given problem. At the same time, pupils should be familiar with the objections of opponents and be able to respond to such objections. The pupils should suggest options to resolve the problem.

CONCLUSION

We provide the results of a questionnaire survey of 60 secondary-school pupils. The results show that 45 % of the secondary-school pupils are interested in information on climate change and global warming. A total of 48 % of the surveyed pupils have encountered the concept of climate change and global warming in the media, which means that the media has become their main source of information on climate change and global warming. The research has shown that pupils stated only 3 terms related to climate change and knowledge in physics which they acquired at primary school: temperature, renewable energy sources and the greenhouse effect. A total of 36 % of the surveyed pupils said, “We measure the temperature”, 21 % said renewable energy sources, 8 % of pupils the greenhouse effect.

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Contact address

RNDr. Libuše Švecová, Ph.D.

Katedra fyziky
Přírodovědecká fakulta,
Ostravská univerzita
30. dubna 22
701 03 Ostrava
e-mail: libuse.svecova@osu.cz

INVESTIGATION OF PROPERTIES OF WATER BY SECONDARY SCHOOL STUDENTS, PRE-SERVICE AND IN-SERVICE TEACHERS

ŽÁK Vojtěch

Abstract

This paper focuses on the implementation of inquiry-based science education (IBSE). The goal of this brief study is to contribute to experience sharing regarding IBSE (specifically investigation of water). From the methodological point of view, the qualitative approach was chosen. This study shows that all participants can benefit from the possibility of choosing from different types of IBSE. We recommend to the participants in IBSE activities to start with a structured or confirmation inquiry and afterwards to continue with a guided or open inquiry.

Key words

Inquiry-based teaching, inquiry-oriented learning, physics

INTRODUCTION

IBSE (*inquiry-based science education*, including *inquiry-based teaching* and *inquiry-oriented learning*) can be seen from different points of view. One of these points of view is how IBSE (a learning activity) is led by a teacher.

Table 1 Types of IBSE according to the teacher's leadership (T = Teacher, SS = Students)

Type of inquiry	Research question	Research methods	Carrying out research	Research results
Confirmation	T	T	SS	T
Structured	T	T	SS	SS
Guided	T	SS	SS	SS
Open	SS	SS	SS	SS

When analysing literature we can distinguish several types of inquiry (see Table 1, compare with Eastwell, 2009; Papáček, 2010; Stuchlíková, 2010, p. 132; Trnova, Trna, 2011; Bílek, Machková, 2015, p. 13; Žák, 2016, p. 303). The basic steps necessary for development of IBSE activities (units) that fulfil main attributes of IBSE is described by Čtrnáctová and Zámečníková (2017).

The goal of this brief study is to contribute to experience sharing regarding IBSE (specifically investigation of properties of water). In connection with this goal, we formulated the following research question: *What characteristics appear to be important when implementing inquiry-based science education?*

METHODOLOGY

From the methodological point of view, the qualitative approach was used to reflect the implementation of IBSE activities in physics education. The basic research plan was a case study. Data were collected using observation of learners working in groups and using an analysis of presentations of the learners, especially their notes made on the blackboard during their presentations in front of the other learners.

The IBSE activities regarding the investigation of properties of water were implemented repeatedly in physics education of several groups of learners – secondary school students, pre-service physics teachers (at the Faculty of Mathematics and Physics, Charles University in Prague) and in-service teachers (their further education). The IBSE activities lasted from approx. 15 min to 45 min. The learners worked mostly in two- to four-member groups. Because we have decided to investigate and reflect IBSE activities qualitatively, the total number of learners included in our investigation is not decisive. We consider the sample to be sufficiently extensive, because the research results show practically useful conclusions.

RESULTS

The results listed below were obtained from the observation and analysis of presentations of the learners. As it will be apparent from the following text, some results may be considered as problems encountered during IBSE activities, others may be perceived positive. In both of these cases, they should be taken into account when implementing IBSE. Several recommendations are made to improve the implementation of IBSE activities.

Perceived lack of time

It was not rarely that the learners felt lack of time to work within IBSE activities. The perceived shortage of time was identified within different groups of learners (secondary school students, pre-service and in-service teachers), even when relatively much time was given to the IBSE activities, e.g. more than one lesson (45 min). It is advisable for the teacher to inform the learners about how much time has elapsed and how much time still remains during IBSE activities.

Problems with tools and material requirements

Especially in cases of the guided and open inquiry (see Table 1), there was a problem that the learners required tools or material that were not available. The characteristics of these types of inquiry include the fact that the learners suggest research methods on their own, and so they also have specific requirements regarding tools and material. Sometimes it was a more expensive device, such as a sensitive scale, sometimes quite common equipment, but a large number of them. We generally recommend to prepare as many as possible things (tools and material) in advance so that there will be no wasting time during the lesson. It is also possible to limit requirements regarding the equipment, e.g. by telling how accurate scale will be available.

Misunderstanding the activity assignment

In several cases the learners were not able to distinguish between an assumption and a conclusion. For example, some learners did not understand why they should determine density of water when they knew that it was 1 000 $\frac{\mathrm{kg}}{\mathrm{m}^3}$. They underestimated the meaning of the assignment *verify that density of water is approx. 1 000* $\frac{kg}{m^3}$ (see Table 1, confirmation inquiry).

Problems connected with open inquiry

It can generally be said that the open inquiry is the most difficult of all types of IBSE (see Table 1). In the lessons which were investigated and reflected, there was not a completely open inquiry, but the IBSE activities were defined by a relatively general instruction, e.g. *Investigate properties of water!* or *Investigate water evaporation!* The learners had to decide in the first phase of the lesson how to define the research question (problem) more precisely to be able to solve it (at least to a certain extent) within the given time (see perceived lack of time above). We recommend that the learners formulate the research questions in a very specific way (with an eventual help of the teacher), especially depending on the given time and experience of the learners.

Formulating and choosing research questions can be conceived using brainstorming within each group of the learners first, then within the whole class, and finally, the most appropriate proposals are chosen. We recommend the teacher and learners to take into account available tools, devices, material, etc. (see problems with tools and material requirements above). It is not necessary that each group investigates a research problem different from the others; on the contrary, solving the same research question by several groups of learners can be beneficial for all the learners. They can compare different methods they have used and their achieved results.

Different ways to present research results

It is advisable to give the learners freedom in what form the research results will be presented. There are examples of four different ways to present data regarding the investigation of water evaporation conducted by pre-service physics teachers. Their investigation took approx. 30 min, the preparation of their presentations 7 min and each of four groups had about 3 min for their presentation in front of the others.

According to our experience even a brief presentation immediately after finishing inquiry can show essential characteristics of the work of learners. In the first case (Fig. 1a, left above), the procedure of inquiry and results are expressed verbally. Regarding the physics content, it was confirmed that the greater the surface area, the faster evaporation occurs. This investigation can be classified as a combination of open and confirmation inquiry and it is qualitative inquiry as well.

In the second case (Fig. 1b, right above), measured values are presented in the form of a table. The mass loss was investigated depending on what was (happening) on the water surface (an uncovered vessel, a covered vessel, a ventilator, an oil layer on water). Not only mass loss, but also temperature change was investigated. While the measured values of mass loss were expected in a similar way, the increase in temperature in the case of the ventilator (last but second row in the table) was surprising for the learners. This question remained open at the end of the lesson, similarly the question how to determine the specific heat of evaporization of water based on the measured values of mass (Fig. 1b, below).

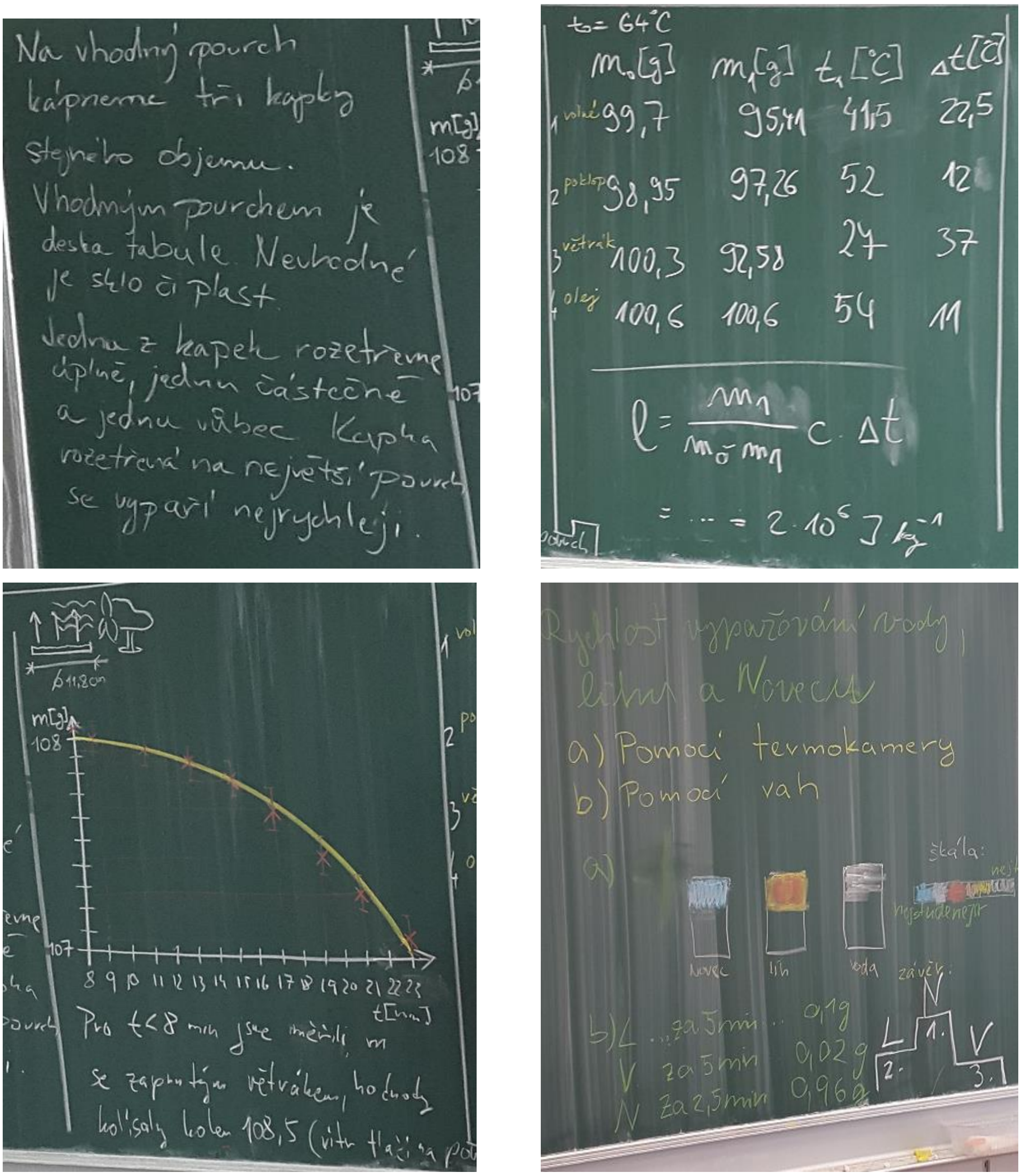

Fig.1 Several ways to present data regarding the investigation of water evaporation: (a) verbal expression, (b) table, (c) graph, (d) another graphical representation

In the third case (Fig. 1c), the learners constructed a graph of water mass versus time. They were surprised that the dependency was concave (a convex function was expected). This contradiction remained unanswered at the end of the lesson.

The last presentation (Fig. 1d) is interesting because the learners requested the teacher to lend them a thermocamera (except a scale). They decided to compare rates of evaporation of water, ethanol and NOVEC. The results were expressed imaginatively both by using a colour scale and by the "winners' podium".

Influence of experience of the learners on the course of IBSE activities

With regard to different experience with IBSE that different learners (especially pre-service and in-service teachers) have, we recommend giving them freedom to choose what type of inquiry they will do. We can start with the general instruction (open inquiry, see Table 1) *Investigate properties of water!* or *Investigate water evaporation!* (see problems connected with open inquiry above). Then we can conduct interviews with less experienced learners and offer them more concrete research problems, e.g. *Compare evaporation of hot and cold water!* (guided inquiry). The teacher can also specify research methods, e.g. *Determine density of water using a scale and a graduated cylinder!* (structured inquiry).

We can prepare a set (a stack) of sheets for each group of learners, where the first one contains the most general information and this is gradually specified on the following sheets (from open to structured or confirmation inquiry). It is up to the learners how much specific information they use.

CONCLUSION

The research revealed several characteristics that seem to be important when implementing inquiry-based science education (IBSE): perceived lack of time, problems with tools and material requirements, misunderstanding the activity assignment, and problems connected with open inquiry. In connection with the perceived lack of time, Baprowska and Bílek (2017, p. 78) point out the importance of good time management within project-based science education. Further, we recommend teachers support different ways to present research results. Special attention should be paid to the influence of the experience of learners on the course of IBSE activities.

This study shows that all participants can benefit from the possibility of choosing from different types of IBSE – confirmation, structured, guided, and open inquiry. We recommend to the participants in IBSE activities to start with a structured or confirmation inquiry and afterwards to continue with a guided or open inquiry. It is beneficial that new research questions have appeared within IBSE activities and that they can serve as suggestions for the further inquiry of the learners.

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Contact address

RNDr. Mgr. Vojtěch Žák, Ph.D.

Katedra didaktiky fyziky
Matematicko-fyzikální fakulta
Univerzita Karlova
V Holešovičkách 2
180 00 Praha 8
e-mail: Vojtech.Zak@mff.cuni.cz

VYUŽITÍ VÝPOČTŮ V ÚLOHÁCH PŘÍRODOPISU

Using calculation in the biology tasks

HLAVÁČOVÁ Lucie, HYBŠOVÁ Aneta

Abstract

Science process skills the ability to compute some variables and to work with measured values, tables and charts. According to PISA 2015 Czech pupils had worse results in these abilities. This research examines if natural sciences tasks have the potential to develop these skills. It focuses on the biological tasks in worksheets. Especially the number and type of tasks requiring numerical computations and quantitative reasoning are mapped. The analysis has shown that this type of tasks is various however it occurs in a low frequency.

Key words

Worksheets, science process skills, biology, calculations, diagram

ÚVOD

Přírodovědná gramotnost je velmi obsáhlý koncept, který podle PISA obsahuje mimo znalostí, dovedností a postojů i celou řadu přírodovědných kompetencí (viz Straková, 2016). Tyto kompetence zahrnují tzv. způsobilost vědecké práce (*science process skills*), jejíž nepostradatelnou roli v procesu učení přírodovědných předmětů charakterizoval W. Harlen (1999). Způsobilost vědecké práce je vnímaná jako porozumění metodám a procesům vědeckého zkoumání (Bilgin, 2006). Padilla (1990) ji definuje jako soubor široce přenositelných dovedností, které jsou využitelné v mnoha vědních disciplínách a které reflektují to, jak vědci pracují. Hodosyová a kol. (2015) popisuje způsobilost vědecké práce jako způsobilost pozorovat, měřit, experimentovat a zpracovávat data. Vzdělávací oblast Člověk a příroda charakterizovaná v rámcových vzdělávacích programech kooperuje se vzdělávací oblastí Matematika a její aplikace (RVP ZV 2016), která mimo jiného obsahuje základní statistické pojmy, čtení z grafů a tabulek (Hybšová, 2017). Právě v těchto znalostech a dovednostech čeští žáci podle studie PISA 2015 zaostávají (PISA, 2015). Podle Mandíkové a Houfkové a kol. (2011) výzkum TIMSS 2007 ukázal, že ve všech přírodovědných testovaných předmětech si čeští žáci nejhůře vedli s úlohami založenými na uvažování. Je tedy otázkou, do jaké míry jsou tyto kompetence rozvíjeny v rámci přírodovědných předmětů a konkrétních přírodovědných úloh. Hodosyová a kol. (2015) se zabývá studiem způsobilosti vědecké práce v předmětu fyzika. V České republice nebylo dosud zkoumáno, jak si v rozvoji dané způsobilosti stojí přírodopis, proto se tento výzkum zaměřuje právě na daný předmět a analyzuje, kolik úloh v pracovních sešitech přírodopisu rozvíjejí znalosti a dovednosti úzce spjaty se způsobilostí vědecké práce a jaká je podoba těchto úloh.

METODIKA VÝZKUMU

Do výzkumu byly zahrnuty ucelené řady pracovních sešitů přírodopisu od všech nakladatelství, které mají schvalovací doložku MŠMT (nakladatelství Fraus, Fortuna, Nová škola, Prodos, Taktik) a akceptují tak obsah Rámcových vzdělávacích programů pro základní vzdělávání (2016). Jednalo se o výběr nejaktuálněji vydaných pracovních sešitů od každého nakladatelství. Celkem bylo analyzováno 22 pracovních sešitů přírodopisu (viz tab. 1).

Tabulka 1: Seznam pracovních sešitů zahrnutých do výzkumu.

Nakladatelství	Název (rok vydání)
Fraus	Přírodopis 6 – Nová generace (2014)
	Přírodopis 7 – Nová generace (2015)
	Přírodopis 8 – Nová generace (2016)
	Přírodopis 9 (2007)
Fortuna	Ekologický přírodopis 6 (2009)
	Ekologický přírodopis 7 (2009)
	Ekologický přírodopis 8 (2009)
	Ekologický přírodopis 9 (2009)
Nová škola	Přírodopis 6, 1. díl – Obecný úvod do přírodopisu (2015)
	Přírodopis 6, 2. díl – Bezobratlí živočichové (2015)
	Přírodopis 7, 1. díl – Strunatci (2015)
	Přírodopis 7, 2. díl – Botanika (2015)
	Přírodopis 8 – Biologie člověka (2015)
	Přírodopis 9 – Geologie a ekologie (2015)
Prodos	Přírodopis 6 – Rostliny (2015)
	Přírodopis 7 – živočichové (2015)
	Přírodopis 8 – člověk (2016)
	Přírodopis 9 (2013)
Taktik	Hravý přírodopis 6 (2015)
	Hravý přírodopis 7 (2015)
	Hravý přírodopis 8 (2015)
	Hravý přírodopis 9 (2015)

Cílem tohoto výzkumu je zmapovat počet a formu biologických úloh rozvíjející způsobilost vědecké práce konkrétně v oblastech jež vyžadují numerické výpočty a kvantitativní uvažování. Objektem výzkumu jsou úlohy v pracovních sešitech přírodopisu. Smyslem je vytvořit výzkumný nástroj, který může být dále využit k hodnocení úloh všech přírodovědných předmětů jako je nejen přírodopis/biologie, ale i fyzika, chemie, geologie a zeměpis/geografie.

Výzkumné otázky:

1. Jakou formu mají učební úlohy v jednotlivých pracovních listech přírodopisu, jež vyžadují numerické výpočty a kvantitativní uvažování?

Kategorizace formy učebních úloh vycházela ze tří základních nositelů numerické informace – text, tabulka, diagram. Na základě toho, jakým způsobem se s numerickou informací dále pracovalo dle zadání jednotlivých úloh, byly vytvořeny konkrétní podkategorie, které jsou uvedeny v kapitole výsledky.

2. Kolik učebních úloh v jednotlivých pracovních listech přírodopisu vyžaduje numerické výpočty a kvantitativní uvažování?

V rámci zaznamenávání úloh v pracovních sešitech byly rozlišovány úlohy klasické a praktické. Za úlohy praktické byly považovány návrhy k laboratorním pracím nebo různým praktickým činnostem, které se svojí komplexností liší od úloh ostatních, jež byly řazeny jako úlohy klasické. Následně bylo zkoumáno, jaký podíl úloh, ze všech úloh v daném pracovním listě, vyžaduje numerické výpočty a kvantitativní uvažování.

V pracovních sešitech se objevovaly úlohy, které ačkoliv obsahovaly numerické údaje, nevyžadovaly jakékoliv kvantitativní uvažování, ale pouze znalosti číselných hodnot, a proto nebyly do výsledků zahrnuty (např. Poloměr Země je _______, Objem krve dospělého člověka činí přibližně _______ atp.). Dále nebyly zahrnuty úlohy, které vyžadovaly prosté sčítání a odčítání bez nutnosti interpretovat výsledek (např. Dětský chrup má 20 zubů a dospělý 36. O kolik zubů více má dospělý jedinec?).

VÝSLEDKY

Kategorizace úloh vycházející ze tří základních nositelů numerické informace byla dle struktury zadání úloh dále členěna do podrobnějších podkategorií (viz obr. 1). První kategorie je zaměřena na způsob zjišťování číselných hodnot, tzn. vyčíst z předloženého textu, z dohledaných informací nebo zjistit samostatným měřením. Druhá a třetí kategorie zohledňuje způsob zpracování daných numerických informací, tzn. zaznamenávat informace do tabulky nebo diagramu, vyčíst informace z tabulky nebo diagramu, popřípadě vytvoření vlastí tabulky a diagramu (viz obr. 1). Jednotlivé vybrané úlohy mohly zahrnovat jednu nebo více ze stanovených kategorií (viz obr. 2, 3).

I. Zjištění numerické hodnoty

a) Ze zadaných informací v textu
b) Z dohledaných informací (na internetu, v učebnicích atp.)
c) Pomocí samostatného měření

II. Zpracování numerické informace v tabulce

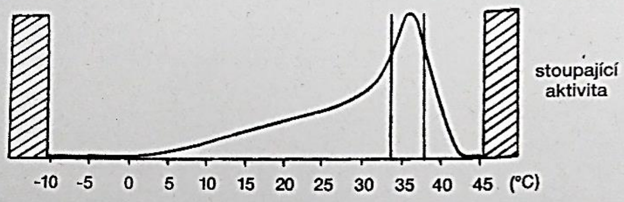
a) Zaznamenání informací do tabulky
b) Vyčíst informace z tabulky
c) Vytvoření tabulky

III. Zpracování numerické informace v diagramu (graf, schéma, časová osa, obrázek)

a) Zaznamenání informací do diagramu
b) Vyčtení informace z diagramu
c) Vytvoření diagramu

Obr. 1: Kategorizace zkoumaných učebních úloh v pracovních listech přírodopisu.

80. Prohlédni si graf závislosti aktivity bekyně mnišky na teplotě prostředí. Pak doplň a odpověz.



Optimální teplota prostředí pro mnišku je ___________. Mniška hyne při teplotě ________________.

Obr. 2: Ukázka učební úlohy zahrnující kategorii III.b (převzato z Fortuna, Ekologický přírodopis 9. str. 20.)

76. Zjisti a zapiš počet tepů u třech spolužáků (A,B,C) v klidu a po námaze (deset dřepů rychle za sebou). Vyber si spolužáky s různou hmotností. Porovnej zjištěné údaje.

Spolužáci	*Hmotnost (přibližně)*	*Počet dřepů* *v klidu*	*Počet dřepů* *po námaze*
A			
B			
C			

Obr.3: Ukázka učební úlohy zahrnující kategorii I.c, II.a. (převzato z Fortuna, Ekologický přírodopis 8, str. 29)

Dle výsledků (viz tab. 2) je patrné, že z klasických úloh, kterých bývá v pracovních listech zhruba 65-260, se úlohy vyžadující numerické výpočty a kvantitativní uvažování objevují sporadicky, tzn. nepřesahují 5 %. Výjimkou je pracovní list pro 6. ročník z nakladatelství Nová škola, kde jsou tyto úlohy zastoupeny z 8,1 %. Úlohy, řazené mezi praktické se vyskytují většinou na závěr pracovního listu a bývá jich podstatně méně než úloh klasických, tzn. 0-25, avšak i mezi těmito úlohami se námi zkoumaná forma úloh vyskytuje pod hranicí 5 %. Výjimkou je pracovní sešit pro 8. ročník, opět z nakladatelství Nová škola, kde se mezi praktickými úlohami vyskytují úlohy vyžadující numerické výpočty a kvantitativní uvažování v 23,5 %. V 5 z 22 koumaných pracovních sešitů se dokonce nevyskytují žádné úlohy vyžadující numerické výpočty a kvantitativní uvažování, jedná se konkrétně o pracovní sešity 6. a 7. ročník z nakladatelství Fortuna, 7. ročník 1. díl z nakladatelství Nová škola, 6. ročník z nakladatelství Prodos a 7. ročník z nakladatelství Taktik.

Tabulka 2: Procentuální zastoupení úlohy vyžadující numerické výpočty a kvantitativní uvažování. V závorkách je uveden celkový počet úloh daného pracovního sešitu.

<table>
<tr><th rowspan="3" colspan="2">Nakladatelství</th><th colspan="8">Ročník ZŠ</th></tr>
<tr><th colspan="2">6.</th><th colspan="2">7.</th><th colspan="2">8.</th><th colspan="2">9.</th></tr>
<tr><td>Klasické úlohy</td><td>Praktické úlohy</td><td>Klasické úlohy</td><td>Praktické úlohy</td><td>Klasické úlohy</td><td>Praktické úlohy</td><td>Klasické úlohy</td><td>Praktické úlohy</td></tr>
<tr><td colspan="2">Fraus</td><td>3,6 % (168)</td><td>0 % (25)</td><td>0,4 % (225)</td><td>3,8 % (26)</td><td>2,6 % (268)</td><td>---</td><td>3,9 % (232)</td><td>0 % (1)</td></tr>
<tr><td colspan="2">Fortuna</td><td>0 % (63)</td><td>---</td><td>0 % (101)</td><td>---</td><td>1,9 % (107)</td><td>---</td><td>4,5 % (111)</td><td>---</td></tr>
<tr><td rowspan="2">Nová škola</td><td>1. díl</td><td>8,1 % (162)</td><td>0 % (6)</td><td>0 % (176)</td><td>0 % (5)</td><td rowspan="2">2,0 % (245)</td><td rowspan="2">23,5 % (17)</td><td rowspan="2">1,0 % (293)</td><td rowspan="2">0 % (5)</td></tr>
<tr><td>2. díl</td><td>1,7 % (172)</td><td>0 % (6)</td><td>1,6 % (193)</td><td>0 % (6)</td></tr>
<tr><td colspan="2">Prodos</td><td>0 % (65)</td><td>---</td><td>0,8 % (120)</td><td>0 % (17)</td><td>0,5 % (199)</td><td>---</td><td>1,6 % (129)</td><td>---</td></tr>
<tr><td colspan="2">Taktik</td><td>0,6 % (164)</td><td>---</td><td>0 % (190)</td><td>---</td><td>1,4 % (144)</td><td>---</td><td>2,6 % (156)</td><td>---</td></tr>
</table>

DISKUZE

V České republice se objevují výzkumy analyzující úlohy v učebnicích přírodopisu (např. Vránová, 2012; Hrabí a kol., 2014). Ve vyučovacím procesu však žáci kromě učebnic pracují také s pracovními listy, což vychází i z výzkumu Hlaváčové (2015). Studie Tikalské (2008), ukazuje, že práce s pracovními listy je pro žáky obdobně atraktivní jako práce s učebnicí.

V současné době však neexistují studie, které by se zabývaly konkrétně analýzou pracovních sešitů, jež jsou didaktickou pomůckou k většině učebnic. V přírodovědných předmětech jsou zkoumány znalosti a dovednosti žáků (např. Hodosyová a kol., 2015). V našem prostředí je však výzkum přírodovědných předmětů z pohledu učebních úloh řešených ve výuce považován zatím za nedostatečný (Lokajíčková, 2015). Vaculová, Trna a Janík (2008) považují (ne)kvalitu učebních úloh (chápáno komplexně v rámci výuky nikoliv jen jako forma zadání v pracovních listech) ve výuce za jeden z mezinárodně sdílených problémů přírodovědného vzdělávání.

Tento výzkum, zaměřený konkrétně na úlohy v pracovních sešitech přírodopisu, ověřil, že úlohy, jež jsou úzce pojeny se způsobilost vědecké práce, konkrétně s dovedností kvantitativního uvažování a práce s čísly, se v pracovních sešitech vyskytují nejčastěji pod hranicí 5 %. Vzhledem k tomu, že RVP ZV (2016), apeluje na skutečnost, že vzdělávací oblast Člověk a příroda kooperuje s oblastí Matematika a její aplikace, dalo by se očekávat, že v pracovních sešitech přírodovědného předmětu jako je přírodopis bude toto propojení zastoupeno více. Jedním z úskalí prezentace předmětu přírodopis je skutečnost, že se jedná o učivo, které má převážně popisný charakter (Hlaváčová, 2017). V takovém případě může být obtížné zaujmout pro přírodopis žáky s logickým učebním stylem, pro které je typické logické myšlení, analýza dat a práce s čísly (Škoda & Doulík, 2011). Větší zastoupení takových úloh v pracovních sešitech by mohlo u žáků nejen přispět k rozvoji způsobilosti vědecké práce ale zaujmout i širší spektrum žáků pro přírodopis.

Z výzkumu je dále patrné, že ačkoliv úloh vyžadující numerické výpočty a kvantitativní uvažování není v pracovních listech mnoho (tzn. většinou méně než 5 %), existuje široká škála forem těchto úloh, tzn. určité úlohy vyžadují nejen pochopení, ale i samostatné tvoření čísel, tabulek a diagramů. Některé úlohy dokonce vyžadují samostatné měření dat a jejich následné zapsání do tabulky nebo diagramu, respektive grafu.

ZÁVĚR

V rámci výzkumu byl vytvořen výzkumný nástroj, zaměřený na analýzu úloh vyžadující numerické výpočty a kvantitativní uvažování v předmětu přírodopis/biologie. Výzkumný nástroj kategorizuje jednotlivé formy úloh dle jejich zadání a celkové koncepce provedení tak, že je možné zjišťovat, zda jsou žáci vedeni k tomu pracovat s čísly ve formě textu, tabulky, diagramu nebo zda jsou směřováni k tomu numerická data sami měřit či vyhledávat. Jednotlivé kategorie jsou stavěny tak, aby byla možná jejich aplikace i na jiný přírodovědný předmět jako je fyzika, chemie nebo zeměpis/geografie.

Vzhledem k tomu, že učební úlohy vycházejí z rozdílné náročnosti poznávacích operací nutných k jejich řešení (Tollingerová, 1970) a různorodosti typů zadání učebních úloh (Byčkovský, 1982) bude výzkum dále rozšířen o kategorizaci zahrnující i kognitivní funkce, jež je třeba k řešení úloh zapojit.

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Contact address

PhDr. Lucie Hlaváčová, Ph.D., Ing. et Ing. Aneta Hybšová, Ph.D.

Katedra didaktiky biologie a enviromentálních studií
Pedagogická fakulta,
Univerzita Karlova
M. Rettigové 4
116 39 Praha 1
e-mail: lucie.hlavacova@pedf.cuni.cz, anetahybsova@gmail.com

AN ATTEMPT TO CREATE A SEQUENCE FOR IMPLEMENTATION OF THE TRADITIONAL TOPIC: MIXTURES

HOŠALOVÁ Martina, HELD Ľubomír

Abstract

Current chemistry pupils currently harbor a lot of preconceptions and misconceptions, and a lot of these contradict scholarly ideas even in topics as basic as mixtures and their separation. Furthermore, many of these misconceptions are caused by traditional schooling. It is for this reason that the deductive approach to education must be replaced with an inductive approach. We have applied didactic reconstruction to the field of chemistry. We have created a series of inquiry-based science education (IBSE) activities to develop pupils' skills in this area. In the present article, we describe two activities in more detail.

Key words

Chemistry, Conceptual Change in Science, Inquiry-based teaching, Primary School

INTRODUCTION

In recent years, reformist efforts in the field of science education have aimed to develop literacy in the natural sciences; that is, in the intersection of three areas: concepts in the natural sciences, competence in scientific work, and a scientific approach to reality and to nature (Harlen, 2010, p. 8-9). Such marked reforms are particularly necessary in chemistry education in Slovakia, where 15-year-old pupils in both primary and secondary school have performed poorly in the Program for International Student Assessment (PISA). Specifically, the 2015 PISA report states the following: "The results of Slovak pupils in the sixth cycle of the PISA international study show a continuing trend towards reduced performance in the natural sciences, mathematics, and literacy. In all areas studied, Slovak pupils obtained scores that were significantly lower than the OECD average, just as in the previous cycle." (Miklovičová et. al., 2017, p. 29). Furthermore, in 2015, the deterioration in results was worse than in the previous four cycles (Šiškovič, Toman, 2014, p. 1-16). For this reason, a change in the content of natural science education is necessary. That is, the specific topics and concepts of natural sciences that are included in the syllabus must be revised to put more emphasis on experimental activities carried out by the pupils themselves. This would develop the pupils' scientific competence. In fact, experimentation and scientific competence are the main indicators of performance under the

PISA system. On the basis of the didactic reconstruction model (Jelemenská et al., 2003, p. 190-198), we have proposed a change in the approach to teaching basic introductory themes in chemistry.

MISCONCEPTIONS IN THE TOPIC OF MIXTURES

Even though the content of chemistry education follows a traditional formula and is relatively simple, pupils harbor a number of preconceptions that run contrary to scientific ideas, as well as misconceptions that schools are unable to remove, and in some cases even cause. Moreover, teachers fail to allow enough time for the pupils to develop correct preconceptions, and they rarely address misconceptions. The topic of mixtures is considered rather trivial, and didactic research does not devote enough space to it. However, it should not be overlooked, because it constitutes the starting point of chemistry education (Harlen, 2010, p. 28).

Therefore, for the purposes of the present report, it will be useful to outline and describe the misconceptions that occur in this area (Kingir et al., 2012, p. 1650; Can, Boz, 2014, p. 17). Specifically, these studies, which recorded the claims of pupils themselves, reported the following misconceptions about the topic of mixtures:

- The presence of an insoluble material proves that a mixture can be classified as heterogeneous.
- Saturated solutions contain insoluble materials at the bottom.
- Homogenous mixtures are pure materials.
- Mixtures that contain water are homogeneous.
- All mixtures are heterogeneous.
- Mixtures are always composed of two materials.
- The identity of the components of a mixture is not preserved.
- All solutions are liquids - only liquids can be solutes.
- Solutions can occur as either liquids or gases - solids cannot dissolve other solids.
- Solutions can occur as either solids or liquids - gases cannot be dissolved or be solutes themselves.

These claims show that pupils regard visual assessment as the deciding factor when classifying a material. They do not think about the internal structure of that material; their conflation of the terms “homogenous mixture” and “pure material,” as well as the terms “unsaturated solution” and “insoluble material”, confirm this. Pupils do not usually consider mixtures that are composed of more than two materials. Similarly, they are convinced that solutions are always liquids and they do not consider whether solutions can occur in other states. They generally consider water a solvent, because it is commonly presented in textbooks as the universal solvent. For this reason, they do not believe that a gas can be a solvent, or that solids can dissolve other solids.

With regards to the topic of separating mixtures, pupils make claims that contradict scientific notions. Can and Boz (2014, p. 17), who focused on various misconceptions in pupils aged 14–16, stated the following:

- Filtration is a method of separating solids from liquid solutions
- Distillation is a general method of separating liquid/liquid mixtures.

Pupils have deep-seated misconceptions about the notion of filtration, because they work with a contaminated liquid and a filtration apparatus (laboratory stand, filter funnel, filter circle, and filter paper). However, they do not consider filtration within its whole context (Filtration is the separation of solid particles from a gas or liquid.).

The pupils' notions of chemical materials, and about chemicals themselves, are also unsettling. Current textbooks have failed to improve the negative image of chemicals in society, because they use the inadequate term "chemical material" rather than the adequate term "chemically pure material" (Adamkovič et al., 1993, p. 18, 40, 48). It is clear that the use of this incorrect term (chemical material), which has strong emotional connotations, can markedly influence pupils', and ultimately the public's, relationship with chemistry.

This artificially created negative attitude towards chemical materials leads to a natural confusion among the terms "pure/purification" and "clean/cleaning," because the Slovak language, as it is used in the classroom, does not distinguish these words. In turn, the concept of washing is also conflated with the notion of chemical purity, particularly when water, as the most common liquid, is used to wash materials. It is important that education professionals take into account the differences between everyday and scientific meanings of terms. In everyday use, the term "clean" ("čistý" in the Slovak language) is used to mean (1) that which pays attention to cleanliness (unsoiled, washed, unadulterated, sterile), (2) that which does not carry any traces of interference (blank), (3) unmixed with anything (pure, transparent, crystalized, genuine, 100%), (4) honorable (without fault) (Anettová et al., 2004, p. 76-77). However, in scientific discourse, the term "pure" (also "čistý" in the Slovak language) is defined as "a certain structural characteristic of an element or compound whereby the material is composed of the same types of particles arranged in the same way (atoms of one or more elements, ions, molecules, or molecular complexes) (Klikorka et al., 1989, p. 153). As a result, pupils perceive tap-water as clean (blank) and then automatically identify it as a chemically pure material, but it is mixture.

Pupils can develop a negative relationship with chemistry because of chemical equations, which they acquire through mechanical learning (Veselský, Hrubišková, 2009, p. 13-14). Therefore, education professionals must introduce to the curriculum other ways of identifying the contents of a solution so that the pupils can acquire the information through meaningful learning. One simple, graphic method of finding the contents of a solution is the visual colorimeter, which is an optical, somewhat subjective method that compares color intensity between a solution of unknown concentration and one that contains a known amount of the same material, known as a standard (Majer et al., 1989, p. 186).

The mixture or interaction of materials can give rise to mixtures or to new materials. Mixtures, unlike newly-created materials, can be separated using separation methods such as filtration using filter paper. In fact, this separation technique is introduced in primary school, as well as in secondary school and even in university. However, in everyday life and in the home, pupils encounter completely different approaches to filtration. For this reason, the method must be enhanced using various filtration materials (grit, sand, foam, newspaper, etc.) because such means are regularly using in everyday life (sand filters in pools, activated carbon in aquariums, gravel filters in sewage treatment plants, etc.).

In the same way, as they progress through school, pupils come into contact increasingly often with terms like “distillation,” “adsorption,” or “crystallization.” Therefore, it is appropriate that pupils gain extensive experience with these techniques and understand their basis. In art or natural science activities at primary or pre-primary levels, pupils can gain experience with chromographic phenomena. Therefore, it is natural that chromatography, which is often used to separate materials from a mixture in practice and in the media (criminal dramas)-found its way into the school curriculum as a method of separating materials.

An attempt at didactic reconstruction of a traditional theme: Mixtures

Many studies have shown that pupils harbor various misconceptions because of the way in which current natural sciences curriculums are chosen. Therefore, educators must find sophisticated solutions based on a comprehensive and relatively stable concept of natural science literacy that supports an inductive approach to natural sciences education. Wynne Harlen and Michael Reiss formulated just such an approach in their publication “Big Ideas in Science Education” (Harlen, 2010, p. 21-23).

The topic of mixtures and their separation falls under a proposition entitled “All materials around us are composed of very small particles.” Our goal is to break this concept down into smaller parts and ideas. We addressed the topic of mixtures as follows: “If some materials interact, they create new materials that have different properties form the original materials. Other materials mix without permanent change and can be separated again.” Subsequently, we established a didactic sequence as a series of necessary steps that must be adhered to so that pupils can learn in a meaningful way.

1. The study of empirical evidence that materials commonly perceived as pure (e.g. water or air) are mixed materials or solutions.
2. The terminological distinction and classification of heterogeneous mixtures such as foam, smoke, suspensions, and emulsions, as well as the perception of homogeneous mixtures (solutions) in a variety of states.
3. The empirical study of the properties of several mixtures, and comparison between these and chemically pure materials. The stability of physical properties.
4. Determining the contents of a solution. Empirical identification of the contents of a solution (visual colorimetry, viscosity measurement, etc.)
5. Experimentation using a number of techniques (filtration, distillation, crystallization, chromatography, adsorption)

Next, we worked this didactic sequence into a number of Inquiry-based Science Education (IBSE) activities, which take an approach similar to that of scientific research, although they are accommodated to the age of the pupils. The names of the activities are connected to everyday life and do not contain specialist terminology, which might put pupils off:

- Is pure water really pure? (*exploring mixtures*)
- Is one look enough to discover the contents of a solution? (*determining the contents of solutions using visual colorimetry*)
- Which filter is best? (*separating the contents of a mixture using separation methods – filtration*)

- How does activated carbon help with stomach problems? (*separating the contents of a mixture using separation methods – adsorption*)
- Detective story: there's black and then there's black! (*separating the contents of a mixture using separation methods – chromatography*)

Some examples of the IBSE activities at the International Standard Classification of Education level 2 (ISCED 2)

Created activities for the mixtures topic, which is subject of traditional curriculum at the ISCED 2 level, are in accordance with inquiry-based science education. The activities are generally available and recognizable. The benefit of this study is based on the fact, that we have elaborated the activities in such procedures, that are not only interesting, but also manageable and appropriate for pupils. The study will further describe the activities with the title: "Is pure water really pure? " and "Detective story : there's black and then there's black!".

1. *Is pure water really pure?*

This activity shows that, even though water is a colorless liquid with no taste or smell, it cannot be classified as a chemically pure material. It may contain various minerals that cannot be seen with the naked eye and is therefore a mixture.

The pupils work with various types of water-tap water, distilled water, rainwater, and mineral water (Vincentka, Fatra Extra strong, Rajec still, Mitická sparkling). The basis of this activity is the method of potentiometry in a very simplified form. Specifically, it comprises the potentiometric study of several samples of water. To carry out the study, we use equipment that measures electrical conduction, namely a 4.5 V battery, colored diodes intended for voltages of 3.5 V, and elastic bands (Fig. 1).

Fig. 1. Equipment for measuring electrical conduction. Source: Hošalová, 2017

The pupils then carry out quantitative observations of the diodes' intensity with a given sample; they record these observations in their workbooks using a four-point scale (0: no light, +: weak intensity light, ++: medium intensity light, +++ strong intensity light). We tested this activity under laboratory conditions and it is possible to clearly distinguish the intensity of the light and to determine the scores on the given scale. On this basis, the pupils judge which sample of water contains the most or least dissolved material (ions), and they arrange the water samples in order. They then verify their measurements using different techniques. The first is to simply check the concentration of dissolved material in the water from the label. The second involves plating 1 ml of each sample onto a polished petri dish and allowing spontaneous evaporation of the liquid. On the basis of all these experiments, the pupils can arrange the samples in order from “least dissolved material” to “most dissolved material”. They can then divide the samples into two groups, chemically pure materials and mixtures.

In this activity, the pupils develop their ability to observe, measure, interpret data, draw conclusions and generalize, and judge and formulate premises and hypotheses. In addition to these skills, the pupils strengthen their reading literacy.

2. Detective story: there’s black and then there’s black!

This activity helps the pupils to understand and explain the term “chromatography”. The activity is designed so that the pupils themselves deduce the basis for this separation technique. The pupils observe the decomposition of colors (green, brown, black, and red) into their individual components and discover that some colors are mixtures that can be separated using chromatography. To carry out this experiment, chalk is used as the stationary phase, water as the mobile phase, and markers of various colors are dissolved in the water.

The information that the pupils discover using these activities can be used to solve the following problem: “*At the end of the lesson, the teacher found that the results sheet hanging on the wall had been tampered with. The winner’s name had been crossed out with a black marker. The teacher found that four of the pupils had black markers. Find which marker was used to spoil the results sheet*.” The pupils should approach the problem by separating the four markers into their individual components (Fig. 2). They should then cut a small sample from the results sheet, pick it up using forceps, wet it for a moment, and attach it to the chalk. Next, they should observe the results and draw a conclusion (Fig. 3). Three of the markers separate into identical components, while one separates into different components. The paper is tarnished with a marker that separates into different components. We use filter paper, which adheres better to the chalk and gives results that are more easily observed.

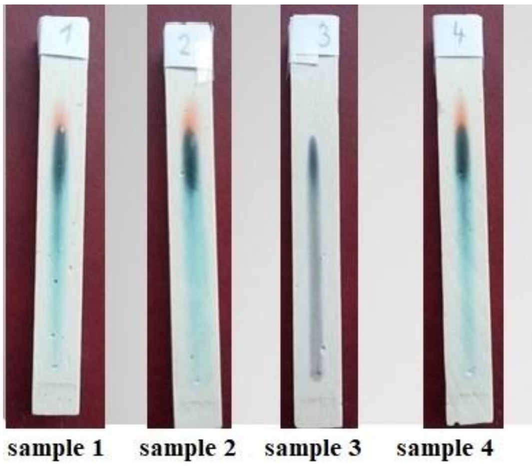

Fig. 2. Separation of black markers into their individual components. Source: Hošalová, 2017

Fig. 3. Assessment of the task. Source: Hošalová, 2017

In this activity, the pupils develop their ability to observe, interpret data, draw conclusions and generalize, judge and formulate premises and hypotheses, and experiment.

All these activities are carried out using worksheets. The pupils' activities are initiated by the stimulating situation, which is introduced on the worksheet as "Preparation". This is followed by a section entitled "Problem and Creation of Premises" in the form of either hypotheses or possible explanations. The worksheet continues with a practical task entitled "Proposed Approach". The pupils can use various approaches, for example observation, searching information resources, models, or experiment. At the conclusion of the worksheet there is a section entitled "Summary", where the pupils have space to work through their results and compare them with their hypothesis, as well as summarize their results and construct terms or explanations. There is also a supplementary task that can be carried out at home or in a school environment called "Assignment". These worksheets take the form of a structured investigation, although the layout of some of the activities could be considered open investigation.

The activities created are currently being tested at six Slovak primary schools in the towns of Pezinok, Sereď, Nováky, Komárno, Košice, and Poprad and at one 8-year high school (Trnava).

CONCLUSION

The international PISA evaluations of 2003, 2006, 2009, and 2012 showed that the results of Slovak pupils are below the OECD average and that the quality of Slovak education is continuously falling. With regards to the perspective natural sciences curriculum of primary schools, we believe that certain current scientific terms should be taught more thoroughly (e.g. adsorption or chromatography), and that activities that allow pupils to develop scientific skills should be prioritized. One of the reasons for our approach is that the PISA tasks do not require a broad knowledge of natural science, which that has been emphasized in Slovakia in the past. Instead, they require that the pupils be able to orient themselves in the kind of data that science, scientists, and scientific institutions present. Thus, pupils must show literacy in the natural sciences and skill in scientific work. In this regard, the Slovak education is markedly lacking. We believe that this situation can be solved by strengthening the experimental and research activities of the pupils. This would require a change from a deductive to an inductive approach to the basic structure of individual natural science concepts. Therefore, we think it will be useful to subject the contents of natural sciences education to a didactic reconstruction. To this end, we have relied on the previously published concept of Harlen and Reiss (Big Ideas in Science Education; Harlen, 2010, p. 21-23). In the present study, we have described our starting points and suggested an inductive approach to one topic. This is currently being tested in schools. We will present the results in the near future. However, the tests have already revealed that the activities have a strong motivational potential.

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Contact address

Bc. Martina Hošalová, prof. PhDr. Ľubomír Held, CSc.

Katedra chémie
Pedagogická fakulta,
Trnavská univerzita
Priemyselná 4
918 43 Trnava
e-mail: hosalova.martina@gmail.com, lubomir.held@truni.sk

A DIDACTIC RECONSTRUCTION OF A TRADITIONAL TOPIC: THE PARTICULATE MODEL OF MATTER

KOCUNOVÁ Jana, HELD Ľubomír

Abstract

This article describes a didactic reconstruction of the particulate model of matter. The topic is presented to the pupils in the form of inquiry-based science education (IBSE) activities. In order to design these activities, it was necessary to familiarize ourselves with the historical development of appropriate notions and to analyze pupils' misconceptions. The activities provide space for the pupils' own inquiry, developing their scientific reasoning skills and allowing them to construct the particulate model of matter through the inductive approach. We present some misconceptions about the topic, the steps in our didactic sequence, and a sample of the IBSE activities.

Key words

Cognitive skills, conceptual change in science, misconceptions, primary school

INTRODUCTION

The particulate nature of matter is an important theory in chemistry. Other areas of chemistry education are connected to and founded upon this understanding of the microworld. It is interesting that almost all pupils are familiar with the widespread scientific term "atom." However, their conceptions of atoms are insufficient and differ from scientifically accepted notions. Pupils are familiar with the definition of atoms as the basic particles of matter; they can describe the composition of the atom and they know the terms "nucleus" and "shell." However, they do not use "particulate reasoning" about matter.

Wiener et al. (2017, p. 6), stated that teachers need not immediately speak to pupils in terms of atoms or subatomic particles when providing an introduction to chemistry. Rather, they should first introduce "particle systems," which are composed of particles and which provide pupils with meaningful knowledge about the particulate nature of matter, without using the term "atom" to refer to the particles of matter. We believe that this approach can eliminate some common misconceptions about the particulate nature of matter.

In the first section of the present paper, we provide an overview of pupils' misconceptions about the particulate nature of matter that have been described in the literature. The sheer number of these misconceptions prompted us to didactically reconstruct the theme of the particulate nature of matter. In the next section, we present our own proposed steps in a new didactic sequence; on the basis of these steps, we designed a series of research-oriented activities. With these activities, we seek to ensure didactic representation for a range of key ideas within the following thesis: ”All material in the Universe is made from very small particles” (Harlen, 2010, p. 28; 2015, p. 20).

PUPILS’ MISCONCEPTIONS ABOUT THE PARTICULATE NATURE OF MATTER

Many of the misconceptions that pupils form in this area arise because problems in chemistry must be conceived on an abstract level. However, this need not necessarily be a barrier to the pupils’ understanding, since we know that children usually encounter these concepts at an age when abstract thinking is beginning to develop, according to Piaget’s theory of cognitive development. Another reason for pupils’ misconceptions is that the particulate nature of matter involves chemistry at a so-called microscopic level that is quite foreign to the pupils. Children are more familiar with the macroworld, in which they can observe various phenomena. However, if we wish to explain some of these phenomena to the pupils, we must pass into the microworld (Nodzyńska, 2012, p. 91), wherein reasoning necessitates abstraction.

Which misconceptions are encountered most often?

- *Matter is only composed of particles when we can see them.* This misconception probably arose because pupils understand matter on the basis of the “seeing is believing” principal (Kind, 2004, p. 9). Pupils do not explain the behavior of matter on the basis of its particulate nature, and therefore they do not “need” particles and, in turn, do not believe that they exist.

- *Atoms can be seen under a microscope, like dust for example* (Griffiths and Preston, 1992, p. 622; Kapici and Akcay, 2016). Other pupils claim that atoms cannot be seen because protons, neutrons, and electrons are colorless, but this explanation is just another misconception.

- *All or some atoms are alive.* Several authors have reported that pupils’ anthropomorphize particles (Griffiths and Preston, 1992, p. 623; Benedikovičová, 2012, p. 81; Kapici and Akcay, 2016, p. 48). Pupils have an anthropomorphized view of the world and they believe that atoms are alive. Papageorgiou et al. (2016, p. 476) reported the following answers of pupils to the question of why atoms are, or could be, alive: *Atoms are the smallest living organism, because cells are composed of atoms. They are* *alive, because they feel and move. During chemical reactions, atoms decide how to bond and what to bond with. Only the atoms inside living organisms are alive. Atoms from inanimate matter are not alive.*

- *Matter lacks permanence—when it disappears from view, it ceases to exist*. Kind (2004, p. 7) reported pupils' perceptions from a number of studies. For example, some pupils stated that when sugar is stirred into water, it disappears rather than dissolves. Similarly, some pupils believed that the water level inside a container falls during a sunny day because the water disappears, and that propane in an open bottle disappears rather than evaporates.
- *Particles have the same properties as their respective material.* Some pupils claim that the properties of particles reflect those of the material they are a part of, and they ascribe macroscopic properties to particles. For example, because iron occurs in a solid state, its particles must be solid; when the iron turns to a liquid, its particles are also liquid (Papageorgiou et al., 2016, p. 476). Kapici and Akcay (2016, p. 49) reported that some pupils claim particles of solid mercury have a different shape from particles of liquid mercury. In another study, some pupils believed that, when matter expands due to heat, its particles also expand or increase in number; conversely, others claimed that, when a material contracts due to cooling, its particles also contract or decrease in number (Ozmen, 2011, p. 104).
- *The properties of a material remain, even though the material disappears*. Some pupils think that matter disappears, but that its taste or smell remains (Kind, 2004, p. 7). For example, they believe that sugar disappears in water, but that its sweetness remains behind in the sweet water, and that the smell of propane remains, even though the material has disappeared.
- *Although particles are separate entities, the space between them is filled and matter is continuous.* It is difficult for pupils to imagine that the space between particles is empty. They intuitively fill it with, for example, dust, other particles, air, dirt, or liquid (Novick and Nussbaum, 1978, p. 276). Others think that there is no empty space between particles, because particles are placed very close together in, for example, solid materials (Aydın et al., 2013, p. 108), so no space is completely empty. Pupils tend to prefer a continuous view of matter. We wish to add that, in a similar way, some pupils

claim that particles are found *in* matter (like raisins in a bun), and not that matter consists of particles.

- *The particles of a material are not in motion, but stationary*. Some pupils fail to ascribe diffusion to the random motion of particles, and they fail to invoke the motion of gas particles to explain why gas in a tank does not fall to the bottom (Novick and Nussbaum, 1978, p. 277). Other pupils do not believe that the particles of a solid move; they claim that the particles are stationary. We think that they come to this false conclusion because the particles of a solid are close together and pupils therefore believe that there is no space for movement.
- *The atom is a ball.* Some pupils imagine an atom as a ball with something inside, or as a collection of balls or similar (Griffiths and Preston, 1992, p. 621). In our opinion, this misconception is caused by illustrations in textbooks. Wiener et al. (2017, p. 6) also emphasized that graphic representations of particles should use images that minimize the formation of misconceptions that compare atoms to commonly used balls. Some pupils imagine particles of a solid as little crystals, dots, or squares.
- *There is no difference between atoms, molecules, and ions.* Pupils do not differentiate the hierarchy in these terms and they consider them synonyms (Papageorgiou et al., 2016, p. 476). Some claim that all atoms have the same size and mass (Griffiths and Preston, 1992, p. 622) and that all matter is composed of the same atoms without distinguishing molecules in, for example, water, or ions in salt (Benedikovičová, 2012, p. 81).

What methods can be used to avoid these misconceptions?

Kind (2004, p. 13) asserted that pupils must be given time, and that the particulate nature of matter should be incorporated into other topics. Furthermore, pupils should work with notional models of matter (Snir et al., 2003, p. 802), which can help them to explain abstract phenomena and to connect the macroscopic, symbolic, and microscopic levels of thinking.

A DIDACTIC RECONSTRUCTION OF THE PARTICULATE NATURE OF MATTER TOPIC AND THE STEPS IN A NECESSARY DIDACTIC SEQUENCE

This large number of misconceptions prompted us to carry out a didactic reconstruction of this demanding theme in chemistry education. It has recently transpired that a superficial understanding of this demanding problem inhibits the meaningful adaptation of other chemical terms and thus prevents opportunities for developing competency within the scientific field. In the present paper, the term "didactic reconstruction" is used to mean a three-step algorithm of pedagogical research comprising a description of children's mental images, an exploration of the development of these images in the context of science, and the construction and iterative optimization of a didactic model (Jelemenská et al., 2003, p. 190-198). The didactic model is explicated in a series of steps (a didactic sequence), that are necessary if pupils are to experience meaningful learning. Each of the steps in the didactic sequence is connected to the pupils' activity. Although we consider the didactic sequence as constituting the necessary steps, the activities can vary. Into our didactic sequence, we incorporated steps that should strengthen pupils' acquisition of fundamental terms and contribute to their development of competence in the field of science.

1. The study of empirical evidence that matter is composed of particles. Experimentation and observation of various macroworld materials helps pupils to create a basic notion about the particulate nature of matter—the microworld. For instance, the notion that particles are so small as to be invisible, but that they also move. Subsequently, by observing the properties of the same materials, or those of different materials, pupils can understand that the particles of a given pure material are the same, and that those of other materials are different.
2. Exploration of the motion of particles in a material and the approximate average speed of this motion, which changes depending on various factors such as particle size and temperature.
3. The space between the particles of a material, and the unconnected nature of particles. Modeling of gaseous, liquid, and solid materials, whose particles differ in their ratios of repulsive and attractive forces, and of the distance between particles, which differs in every material.
4. A demonstration of Avogadro's law using the same volume of various gases; that is, gases with different particulate components under the same conditions of temperature and pressure.

The activities described below follow these steps in the didactic sequence and allow teachers to didactically illustrate the thesis that "all material in the Universe is made from very small particles." We endeavor to connect the basic terms with the ideas of this key thesis.

INQUIRY-BASED SCIENCE EDUCATION IN THE CONTEXT OF THE PARTICULATE NATURE OF MATTER

Inquiry-based science education (IBSE) is inspired by progressions in scientific research. IBSE preserves scientific progression and only accommodates the needs of pupils by posing simple research questions (Held et al. 2011, p. 86). Pupils begin their investigations by attempting to explain certain facts using the mental models that they have. Subsequently, in parallel with scientific progress, they provide an explanation, which they then compare with given assumptions. In this way, IBSE adopts a constructivist approach to education, and the activities we propose have a markedly inductive character. Specifically, we have created a series of IBSE activities in which the pupils act as investigators. They do not accept the information as fact; rather, the inductively designed activities lead them to construct their own particulate model of matter. The activities are focused on developing various scientific skills, such as observation, measurement, and recording of changes. Specifically, we offer the following series of activities so that pupils can construct their own notions about the particulate nature of matter:

- *Searching for atoms* – empirical evidence for the particulate nature of matter and the movement of particles
- *Crystal or quartz* – comparing the particulate nature of the same and different materials
- *What can a porous ceramic container do?* – the motion of particles
- *What influences the speed of microparticle motion?* – the size of particles and their speed of movement.
- *Does temperature also affect the speed of particle motion?* – temperature and the speed of particle motion
- *Do you understand the words "discontinual nature of matter"?* – the space between the particles of matter
- *Model a gas, a liquid, and a solid.* – models of matter
- *The enigma of Avogadro's hypothesis* – demonstrating the falsification of Avogadro's law

Pupils first encounter the particulate nature of matter at the level of the macroworld through the materials they are working with. They then gradually move from researching material to researching the particles of material. By themselves, pupils construct notions of particles that are similar to the conceptions of Democritus. It is not important to create the notion that matter is composed of little balls; instead, teachers should focus on the idea that materials are discontinuous. Pupils induce the particulate nature of matter; they then investigate the motion of particles and factors that influence it, such as particle size and temperature. It is also important that pupils create models of solids, liquids, and gases that help them to explain phenomena that take place at the microlevel, such as the forces and distances between particles. Pupils switch between macroscopic observations and microscopic explanations for those observations. At the end of the series of activities, the pupils' will search for the enigma of Avogadro's hypothesis and then unsuccessfully attempt to refute it. This leads the pupils to a more precise notion of gaseous matter as a premise for later conceptions of the ideal gas.

Several of the activities that we have described are not new for experts in science education. For example, they can be found in the program "FAST 2" (Pottenger et al., 1977, p. 50), and our experiments with porous vessels are well-known in the didactic literature (Pachmann and Hofmann, 1981, p. 211; Pauková et al. 1971, p. 167).

Of course, we have reworked and improved the activities so that they do not require complicated props and can be carried out under the simplest of conditions; that is, in classrooms rather than in laboratories. We have created a meaningful series of activities by arranging into a single series a number of tasks that were previously introduced independently (Held, 2014a, p. 55; 2014b, p. 117; 2016, p. 89; 2017, p. 1718-1722). When preparing these activities for instruction in primary schools, we optimized and improved some of the props. For example, we use injection needles in a syringe system, which allows us to carry out a well-known experiment in primary schools, because the time required for the movement of a given volume of gas into a vacuum can be measured in seconds using a stopwatch. In addition, we simplified the technical work with porous containers so that even pupils can conduct the experiment easily.

Testing of the activities and preliminary results

The proposed IBSE activities are currently being tested in seven Slovak pilot schools as part of the Expedícia project – try, explore, learn – which is overseen by Indícia n. o. The results of these tests will be known one year from now. The preliminary results indicate that teachers take various approaches to research-oriented learning about the particulate nature of matter. Some have stated that the activities are beyond their experience and therefore problematic. Conversely, pupils have a problem switching from the macro to the microworld and concentrating on phenomena that take place in the latter. In our work with gas, we assumed that pupils of a certain age already perceive gas as a material, but it transpired that they have a problem with this idea. Some teachers are gradually gaining the necessary skills to implement this kind of instruction and are trying to create an environment in which pupils can develop their investigative skills in order to create their own particulate model of matter. Another group of teachers adheres well to our experimental methods, but have less expertise in the subject matter and therefore cannot effectively lead the instruction process. A third group of teachers implements the activities well, but cannot come to terms with the planned goals of the instruction and fail to see the point of the topic. We carried out a test of the pupils' knowledge of these materials; in the first preliminary test, pupils failed to show excellent knowledge in the respective field. However, our continuous observations indicate that, when the activities are well-led by teachers, pupils have increased interest and greater independence.

CONCLUSION

The study of the particulate nature of matter requires time and suitable teaching methods that allow pupils to construct scientific concepts. One of these methods is constructivist-oriented teaching, which, unfortunately, is rarely implemented. Therefore, a fundamental change is necessary in the interaction between teachers and pupils.

This study aimed to reveal the various misconceptions that pupils have about the particulate nature of matter so that our readers could become familiar with pupils' reasoning in this area of chemistry and think about whether their methods of teaching encourage these misconceptions. Secondly, we aimed to inform our readers how to didactically reconstruct the theme of the particulate nature of matter using a set of activities that are currently being tested.

We are convinced that it is necessary to implement research-oriented concepts in science education, because such an approach "forbids" pupils from perceiving things incorrectly. We try to show teachers that IBSE activities allow pupils to gain meaningful knowledge rather than simply accept facts, which can cause certain misconceptions to arise. We believe that our tests of these didactic concepts will confirm our assumptions and that the present study will inform teachers how to construct the theme of the particulate nature of matter in future.

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Contact address

Bc. Jana Kocunová and prof. Ľubomír Held, CSc.,

Department of Chemistry,
Faculty of Pedagogy,
Trnava University,
Priemyselná 4,
91843 Trnava
e-mail: kocunova.janka@gmail.com, lubomir.held@truni.sk

MONITORING IBSE ACTIVITIES EFFECTIVENESS BY THE MEANS OF CONCEPT MAPPING IN THE TOPIC OF PERIODIC LAW

BRONERSKÁ Jana

Abstract

Educational material with IBSE activities has been created dealing with the concept of the periodic law and it has been implemented in real school conditions. This conception is focused on pupils´ activity and their skills.

The first group of pupils was taught by traditional deductive approach and the second group by inductive approach. Afterwards, the pupils´ views of periodic law were studied by means of concept mapping. The obtained concept maps undergone qualitative analysis at later stage.

In this article we present the differences in pupils´ ideas about periodic law after being taught inductively and deductively.

Key words

Inquiry-based teaching, concept mapping, misconceptions, knowledge construction

INTRODUCTION

The goal of science didactics is to mediate science knowledge simply, comprehensibly and age-adequately to pupils. Scientific knowledge are abstract and the simplification of some concept can be illogical for pupils and they usually learn it offhand (Čáp, Mareš, 2001). It can be one of the reason for creation some misconceptions. Misconceptions are not a problem only for today´s students, but it was problem for many scientists in the past (for example The Phlogiston Theory), who denied new findings. Getting to know pupils' misconceptions is great source for creation new effective teaching methods and materials.

Chemistry as a science gains its knowledge from 3 different levels of recognizing the outer world (Fig.1). The easiest level from the perspective of learning is macroscopic level. Those are the concepts which we can recognize by our senses. However, if we look into our current teaching-learning materials, it´s obvious, that chemistry education is based on symbolic and microscopic level, which is the most difficult level of learning and it causes incorrect understanding of chemical concepts. (Gabel, 1999).

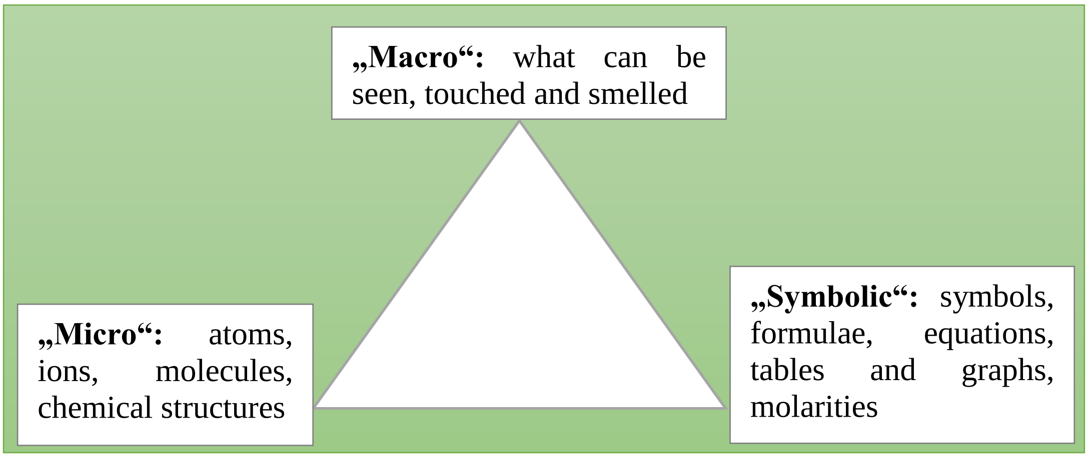


Figure 1 „Chemical Triangle” according to Johnstone (1991)

Scientists, who knows their subject well, and are lets say fully educated in Chemistry or Science, are able to connect the concepts at all 3 levels. However, from psychological point of view, achieving this in students, who meet the new concept for the first time in life, is not possible. Gabel points out, that teachers tend to jump from macroscopic point of view to symbolic level quite radically. The problem here does not come from the base that Chemistry has 3 levels of the concept perception. But it arises from the fact, that the very start of the learning about any chemical concept is being introduced at the most abstract level - the symbolic level. Barke and Hazari remind us that this is the reason how children build up the misconceptions. They emphasize, that many misconceptions, are so called school-made misconceptions. It means that they are caused by incorporating the inappropriate teaching methods (Barke, H. D., Hazari, A., Yitbarek, S., 2009).

Yet, the historical 'evolution' of science concepts being observed, perceived and explained over time, leading to our understanding them today, can be a great source of how to teach students the new science concepts. As the science concepts were defined on the basis of empirical research in the past, the inductive approach towards education can be used to repeat this science 'evolution' process.

The main difference between inductive and deductive approach is its orientation towards teacher or pupil. The deductive approach is oriented towards teacher. It means teacher is more active in lessons. It can be defined by these steps: 1. teacher gives students new concept, 2. he explains it 3. students use this concept in practice. The traditional education prefers this process and this transmission of information.

However, inductive approach utilizes the other way around; students are noticing or finding new phenomenon (for students) and then generalize these findings to create new concepts. The inquiry based science education prefers this process of students´ inquiry activity.

DESIGN OF RESEARCH

We used two methods to obtain misconceptions about the studied concept: firstly, individual deep conversation and secondly, concept mapping. The latter concept mapping has been introduced by Novak and Gowin (1984), who were interested into human learning process and knowledge construction. They built up their approach on Ausubel cognitive psychology. This theory says that learning process is based on assimilation of new concepts into cognitive structure of an individual. According to various authors the concept map is graphical tool, which helps to visualize knowledge by means of drawn relations (Ca*ñas* et. al., 2005, Prokša et al., 2008). The structure of the concept map depends on the context in which it is created. Therefore, the concept maps with the same concepts can vary significantly (Novak, Ca*ñas*, 2008). Concept maps allow us to see students' thoughts structure and afterwards identify the problematic concepts and misconceptions.

Before creating concept maps about the periodic law, it has been shown to pupil how to create a concept map. Firstly, the researcher helped students to create a concept map of photosynthesis. The second concept map they also created together. It contained chemical concepts as solution, solvent, homogeneous and heterogeneous mixture, melted substance, solid, liquid and gaseous solution. After, it has been compared and discussed with all pupils. The third concept map created pupils individually. The instruction given to pupils was: Create a concept map from the following words and describe relations between the pairs of words: *atom, metals, non-metals, metalloids, atomic number, similar properties, element, periods, groups, periodic table of elements, valence shell, number of valence electrons*. Concepts used in the concept mapping method represented macroscopic level of chemistry knowledge (metals, non-metals, metalloids, similar properties, and element), microscopic level (number of valence electrons, valence shell, and atom) and symbolic level (atomic number, periods, groups, periodic table of elements).

The research of students´ ideas in topic the periodic law by means of concept maps was realized in two phases. In the first phase students´ problematic concepts and misconceptions were identified. 84 students, who were taught by traditional deductive approach, participated and they created concept maps. The concept map is meaningful, when all two words are described by relations. If the relations are not identified, the concept map can´t expresses the complete mind structure of pupils. For that reason 10 concept maps were not accepted and only 74 concept maps undergone qualitative analysis which resulted into identification of students´ misconceptions in the topic of periodic law.

Afterwards, the teaching material has been designed on a base of Inquiry-based science education, which incorporated also the misconceptions found in the previous stage of research - concept mapping described above. The topic of periodic law has been taught for five lessons in these five topics: The inquiring of elements´ properties I, The inquiring of elements´ properties II, What are the properties of other elements? From the mess to the system, The table of elements is a table of atoms too.

The second group of the other students was taught by this teaching material too. After these 5 lessons they created their own concept maps from the same concepts as the first group. In this second phase 161 pupils were the research sample and their concept maps undergone qualitative analysis. The result of research compares the concept maps created in first stage before introducing IBSE teaching material and the concept maps created after the IBSE material has been used to teach the students about the periodic law. Based on the results we also try to assess the effectiveness of IBSE activities in periodic law topic.

MISCONCEPTIONS ABOUT PERIODIC LAW

The aim of the analysis was to find out, how the students interconnect the concepts on the different levels of recognition and how they understand them in relation to the periodic table of elements. By means of qualitative analysis of the concept maps and relation in between the concepts we realized some typical ways of connecting of concepts and different interpretations between them.

- **Not clear relation between atom and element**

Periodic table reflects periodicity of properties of elements in macroscopic level of perception, but also reflects the periodicity of the inner structure of atoms of elements. Students are able to observe the properties of elements on sensorimotor level - macroscopic. Properties of atoms, however, depend on its structure, which is not obvious to students´ senses. That is why it is very important to distinguish between atom and element concept. Approximately 24 % of students connected these two concepts on the same level and indicated the 'element to be an atom'. This relation is depicted in the concept map of one of the pupils (Fig. 2).

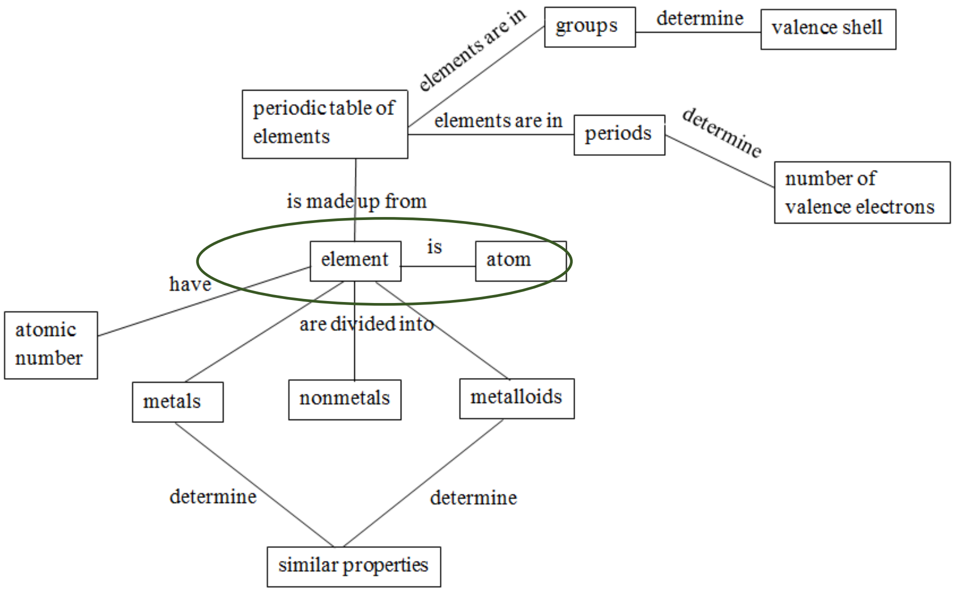


Figure 2 Incorrect understanding of the relation between the concepts atom and element.

• Not understanding of the arrangement of elements into groups and periods on the base of inner structure of atoms of elements

The aim of education in the topic of periodic law is to know the arrangement of periodic table of elements on the base of the inner structure of atoms of elements. With this comes also understanding and interconnection of the set graphical layout with the inner structure of atoms of elements. Based on qualitative analysis of the concept maps prior to the IBSE approach used, 72 % of concept maps shows that this aim hasn't been fulfilled.

• Metals, metalloid and non-metals are elements with similar properties

In all concept maps the students showed that they realized that the groups of the periodic table of elements are metals, metalloids and non-metals. In 28 % of concept maps there was an interconnection with similar properties, or metals and metalloids as elements with similar properties. In 56 % of concept maps there wasn't interconnection between similar properties with the layout of the periodic table of elements. In figure 3 there is a concept map of a student, which shows that student consider all 3 groups of elements to be similar.

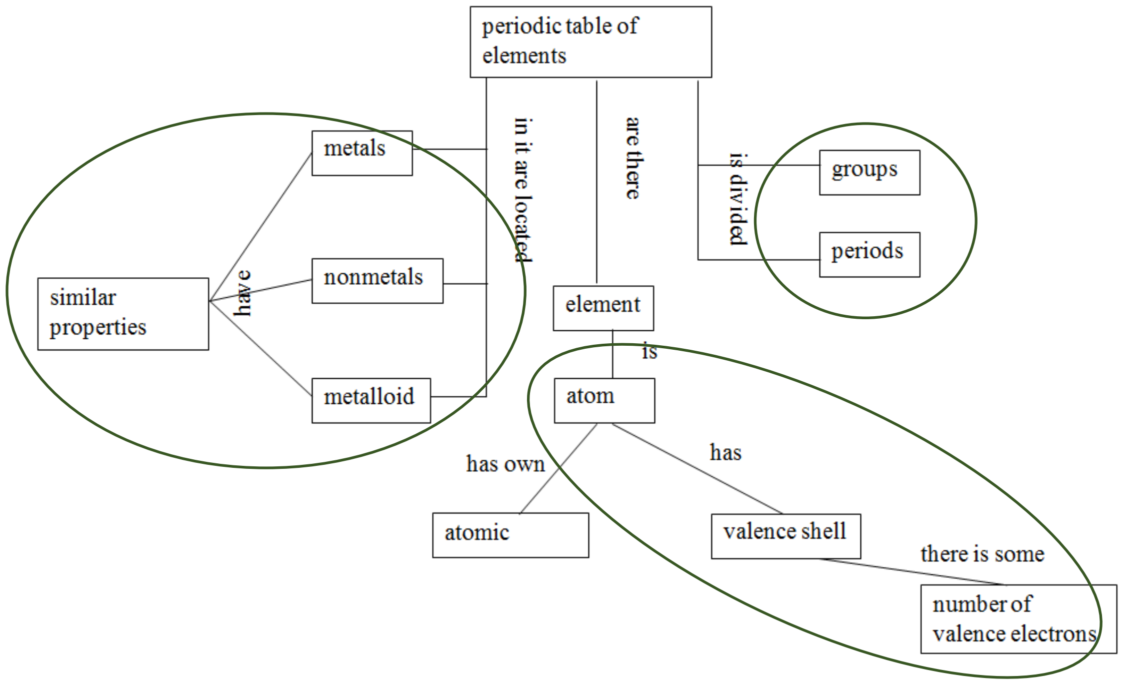


Figure 3 The concepts group and period are not interconnected with inner structure of atoms. Metals, metalloids and non-metals have similar properties.

IBSE ACTIVITIES

An important part of chemical education is periodic law and therefore it´s very natural that many researchers are dealing with the inductive and deductive approaches and methods when it comes to teaching. IBSE is a conception of education which utilizes inductive approach to knowledge gaining.

We obtained the overview of the scientific evolution of system of elements by means of the *didactic reconstruction method*. Copying this historical process of discovery is inductive way of gaining the knowledge and we utilized this approach when creating the teaching-learning material. During the lessons students examine the properties of elements on their own. From their observations they conclude the periodicity in the similarities of the elements.

The design of the lessons aimed at building up the knowledge on the macroscopic level, which naturally interconnected with symbolic level, i.e. creating of periodic system of elements. Only after interconnection of those two levels, we switched to the most difficult level (microscopic). This logical process creating of knowledge on different levels might be the way, how the students gain complex view at periodic system of elements, moreover be able to presuppose the properties of elements on the macroscopic level and microscopic level from the position of the element in the periodic table.

Design of teaching-learning material

An important part of chemical education is periodic law and therefore it´s very natural that many researchers are dealing with the inductive and deductive approaches and methods when it comes to teaching.

On the basis of the found misconceptions we created teaching-learning material, which consists of 5 lessons. During the first two lessons students examined the properties of selected elements and then they wrote their observations on prepared cards. On the third lesson they were looking up the properties of elements in prepared brochure. On the following lesson students created the system of elements from the cards, which they have prepared in the first 2 lessons. They were taking into consideration several different ways of ordering the elements. On the final lesson students had cards, on which opposite side there were depicted the inner structures of atoms of elements. The aim was to find out if there was any relation between the order of the elements and the inner structures of atoms of elements. As a result they found out that the periodic system of elements is the system of atoms too.

RESULTS OF RESEARCH

9-12 weeks after using the IBSE teaching-learning material, the second concept mapping took place, which aimed at effectiveness evaluation of the IBSE activities. We paid attention especially on the misconceptions, which were found in the first concept mapping, before using IBSE material.

- **connection: relation between atom and element concept**

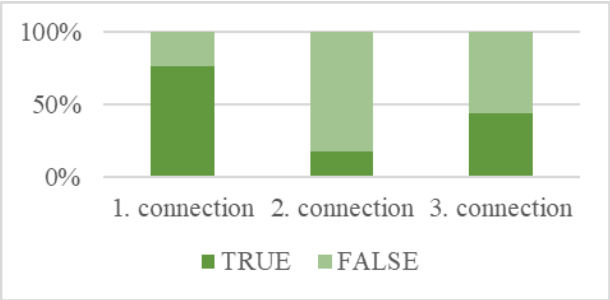
Summarizing up, in the first two graphs, which resulted from the first concept mapping before using IBSE activities, we can see that 24 % of students said, that atom is element. After IBSE lessons, in the second concept mapping, this misconception reduced to 18 %.

- **connection: graphical layout of periodic table of elements (groups and periods) is interconnected with the inner structure of atoms of elements (valence shell, number of valence electrons);**

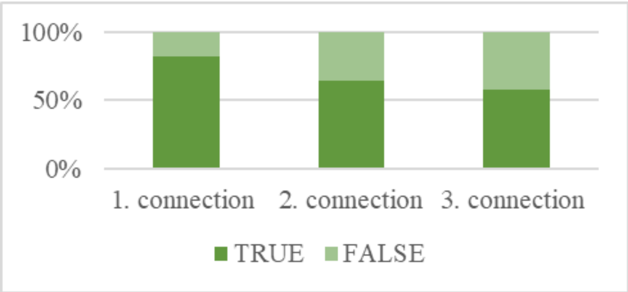
From the graphs, it is clear, that the IBSE activities were most influential in the area of interconnection the concepts from symbolic level (periods and groups) with the concepts from microscopic level (valence shell and number of valence electrons). After introducing the IBSE teaching-learning model, 64 % of students created correct relations in between those concepts. Whereas, before using IBSE model, this number barely reached 18 %.

- **connection: true using of the concept similar properties**

The data from the first concept mapping, before using IBSE approach, brought the information, that 56 % of students incorrectly connected the concept *similar properties* with the other concepts. At that stage, students haven't realized that similar properties of elements are the basis for creating the periodic system of elements. Moreover, 28 % of students stated, that metals, metalloids and non-metals have similar properties or metals and metalloids have similar properties. This relation was confirmed by pupils´ answers. If pupil connected the concept similar properties with groups (metals, non-metals and metalloids or metals and metalloids) we asked pupils the explanation of this connection. The explanation was that these three or two groups are similar. However, after IBSE teaching approach, 58 % of students bearded this fact in mind and connected this concept with periodic system of elements and groups.



Graph 1 Results of the first concept mapping



Graph 2 Results of the second concept mapping

Concept map in figure 4 is one of several concept maps from the students who created them after IBSE lessons with topic periodic law.

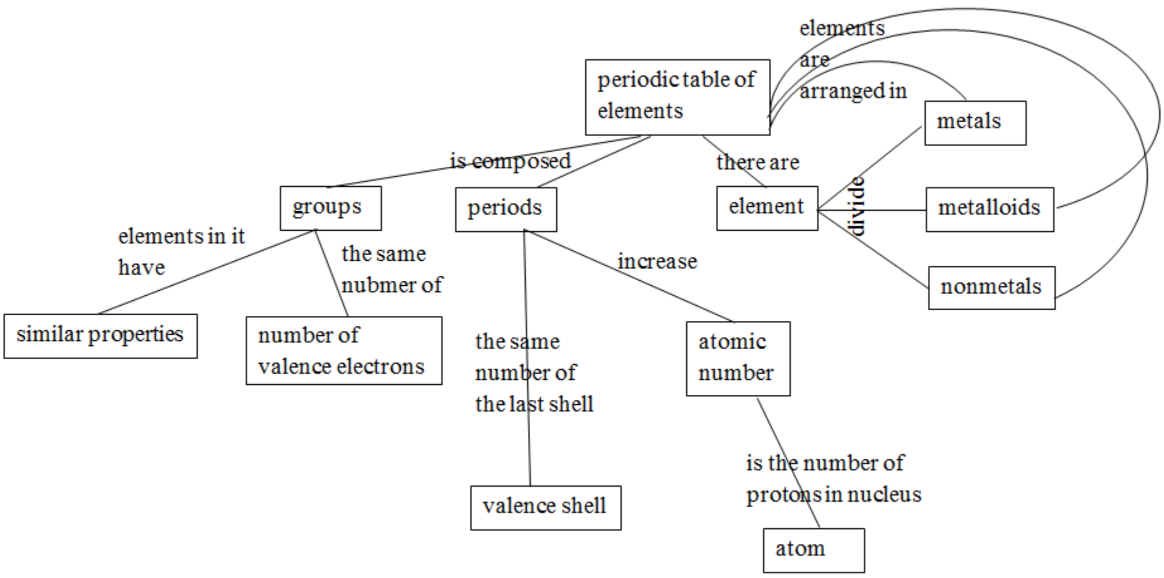


Figure 4 Student's concept map after IBSE approach took place

CONCLUSION

Teaching-learning process, which utilizes IBSE activities, is based on inductive approach to knowledge gaining. If the students research and make their own conclusions, the lessons are effective and the students obtain long-term knowledge.

The research into students' misconceptions in the topic of periodic law brought the conclusion that after introducing the periodic law concept using the inductive approach, students gained deeper knowledge and were able to interconnect the concepts in concept maps logically. They realized the relation of the concepts at the different levels of knowledge and understood the construction of periodic law, because students 'discovered' this system on their own during the lessons. The misconceptions were present in these students less than in the students who were taught by traditional, mainly deductive methods. The results of concept mapping shows, that the inductive teaching-learning process is more effective than the deductive teaching-learning process.

Acknowledgement

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Contact address

Mgr. Jana Bronerská, PhD.

Department of Chemistry
Faculty of Education
Trnava University in Trnava
Priemyselná 4
918 43 Trnava
e-mail: jana.bronerska@truni.sk

EDUCATIONAL PROJECT – WHAT IS HIDDEN INSIDE THE FISH?

KOPEK-PUTAŁA Wioleta, NODZYŃSKA Małgorzata

Abstract

This document presents the implementation of classes having the nature of an educational project and involving 17 children taking part in the activities of the Explorers Club. As part of the classes, students studied selected issues within natural sciences subjects, including biology, and completed an educational project whose topic was: What is hidden inside the fish? The article specifies the main project objectives and its outline. In addition, it presents the analysis of the research questionnaire (pre-test and post-test) and the evaluation questionnaire. In the pre-test and post-test, the increase in the students' knowledge was examined, and the evaluation questionnaire was used to obtain the participants' opinions on the project implementation.

Key words

Cognitive Development, Cognitive Skills, Learning by Design, Project based Learning

INTRODUCTION

Post-mortem examinations of animals are perceived as a quite controversial aspect of the practical teaching of biology (e.g. Hug, 2008; Havlíčková, Bílek, 2015). For this reason, few teachers implement the topic in class. However, there are schools that perform practical specimen dissection (e.g. Florek, Ściborska, 2016). Sometimes this topic is implemented in a practical way, for instance, in the special-interest clubs, and in biology class, it is replaced by other alternative methods (e.g. screening of a film or animation, seeing an already dissected model). With the development of information and communication technology, another alternative also emerged – the virtual post-mortem examination (Doleżych, B., Doleżych, S., 2017) or the use of the combination of the post-mortem examination and the alternative method (Cross, T. R., Cross, V. E., 2004, Havlíčková, Bílek, 2015). The results of some studies indicate that teachers identify strengths and drawbacks to both dissection and alternatives, but the majority continue to strongly favour traditional dissection and see it as vital to biology education (Oakley, 2012). Not many people realize that in the kitchen, some of these treatments are a common activity, which does not create controversy. Most empirical studies indicate that practical work is beneficial for students' motivation (Holsternmann et. all, 2010; Wilde et. all, 2012; Janštová, 2017). Therefore, it was decided to check whether the dissection of fish skeleton by the students and preparing it as a museum model would positively influence the increase in students' knowledge – this was a research hypothesis.

Selected project objectives for the student. As part of the project, the student should, among others:

- consolidate selected information regarding the morphological and anatomical structure of the fish and identify and label selected structure elements on the model,

- find and acquire basic information as well as gain practical skills regarding the dissection of fish skeleton, develop creative and critical thinking skills, among others by observing the specimen and making a maquette with the dissected fish skeleton.

Selected project objectives for the teacher:

- eliciting information from students about whether they eat fish, and whether they pay attention to its structure (morphological and anatomical) and the relationships resulting from it,

- getting an answer to the question whether the self-made maquette will help to organize selected information about fish,

- arousing or sustaining interest in natural sciences subjects (especially biology) and the surrounding world among students.

Project outline: Step 1 Selection of the educational project topic

Discussion on areas of interest of students in the field of biology and the selection of issues discussed during the block of these classes, including those implemented by the project.

Step 2 Definition of the project objectives and stages

Joint planning by students and teachers regarding the goals students would like to achieve, necessary project stages for its successful implementation, and people to whom the effects of the work will be presented.

Step 3 Checking the level of knowledge before starting the task

Taking a pre-test checking the already possessed knowledge about the number and type of fins, body color, known species and location of the fish skeleton and individual bones in the skeleton.

Step 4 Searching for information and performing scheduled activities

Searching for the theoretical information necessary for work on the project and joint planning of the course of action according to which the dissection will be performed. The search for information about fish includes: general information about fish, techniques used to dissect fish skeleton, necessary tools and protective clothing, and a way of making a permanent maquette of a specimen. Then, getting into 2 or 3-person teams and completing the task. Finishing the dissection is followed by making the maquette, permanent placement of the convex fish skeleton according to the individual ideas of each group and labeling the dissected elements.

Step 5 Checking the level of knowledge after performing the task and project evaluation

Taking a post-test and filling in the evaluation questionnaire regarding feedback on classes. The post-test contains questions which the participants first answer in the pre-test, the evaluation sheet contains questions about: how interesting the project classes are, the degree of difficulty and the willingness to participate in another similar project. In addition, there is a brief exchange of participants' views on the degree of difficulty of the task and why it is worth learning about some biological objects in the natural form.

Step 6 Public presentation of the educational project results

Presenting the work results to the parents, teachers and students in the school. Presenting the photo gallery of the received specimens in the center in which the classes are conducted.

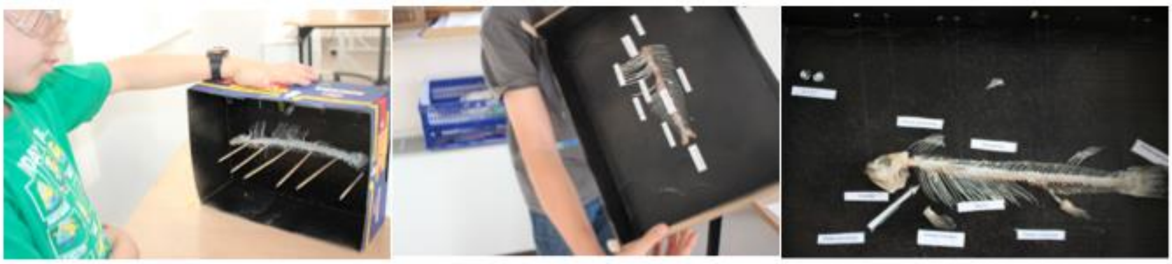


Fig 1. Exemplary fish maquettes

RESEARCH METHODS, RESULTS

This article presents an analysis of the results of a research questionnaire on the experimental studies, in which the dependent variable was the increase of knowledge. During the analysis of the results, various measuring scales were used depending on the content of the question.

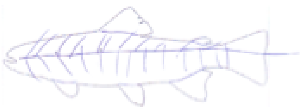
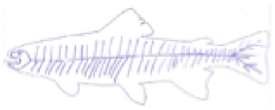
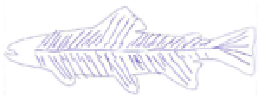
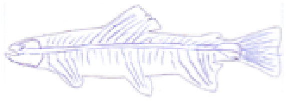
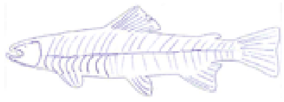
As part of **Question 1**, the students were supposed to draw the skeleton of a fish into its schematic drawing. To assess the correctness of pre-test and post-test answers, the nominal scale (and, in fact, dichotomous: YES/NO) was used, comparing whether the drawing after the dissection of the fish contained more details than the first one. (This is due to the fact that the initial knowledge of students was varied and the initial drawings of individual students differed significantly). **Questions 2-4** concerned the number of fins, the division of fins into odd and even, and the place of occurrence of dark meat in the fish. In the analysis of the answers to these questions, an ordinal scale was used to rank students' responses according to the category of answer: wrong (no answer, 'I do not know', incorrect answer), partially correct and correct. **Question 5** checked how many names of different fish species are known by students – an interval scale was used in this question. The article also discusses the results of a short evaluation questionnaire on students' opinions about the classes and shows the final effect of students' work in this project – a maquette with the dissected specimens.

- Increase in knowledge

Question 1: The shape of the trout is schematically drawn below, **draw the skeleton inside the fish**. Try to mark all the fish bones.

The drawings in the pre-test were mostly chaotic and not very precise, missing some bones or skeleton of the fins, or there were no drawings at all (4 people). Whereas, all students completed this task in the post-test. Drawings (schematic) definitely more accurately reflected the general outline of the skeleton, sometimes with the marking of the correct shape of the bones (their convex shape and direction). Drawings made were more detailed; there appeared the tail fin skeletons drawn correctly, and often the skeletons of other fins (Tab. 1). A large number of bones in some drawings may result from the accuracy of the preparation. Commitment in the preparation could lead to the feeling of being overstated to the actual amount of bones as seen in some drawings.

Tab 1. Exemplary skeleton drawings drawn by students in the pre-test and post-test (own elaboration)

Test/Student	**1**	**2**	**3**
Pre-test			
Post-test			

Comparing the pre-test drawings of individual students with their post-test drawings, a significant increase in knowledge regarding the structure of the fish skeleton and the distribution of individual bones can be noticed. It can therefore be concluded that the fish dissection significantly contributed to the extension of knowledge regarding the structure of the fish skeleton in all students. What resulted from conversations conducted during classes with students who could not draw a fish skeleton was that their whole life they had been eating fish with their bones – however, they still did not know how to draw a skeleton. Only after the dissection classes, when they had to focus on individual elements of the skeleton or fins, did they gain knowledge about the structure of the fish. This example shows how the action or observation (when eating fish) not directed by the teacher may not become a source of knowledge.

Question 2: How many fins does the fish have?

In the pre-test, 16 students answered the question incorrectly. One student wrote "I do not know" and 13 students gave an incorrect answer (among who probably 7 students counted the fins shown in the figure in question 1). Only 1 person gave the correct answer. In the post-test, 7 students gave an incorrect answer (probably 4 students counted the fins shown in the figure in question 1, and 1 student did not answer the question). The number of wrong answers declined significantly and, at the same time, the number of correct answers increased (10) (Fig. 2).

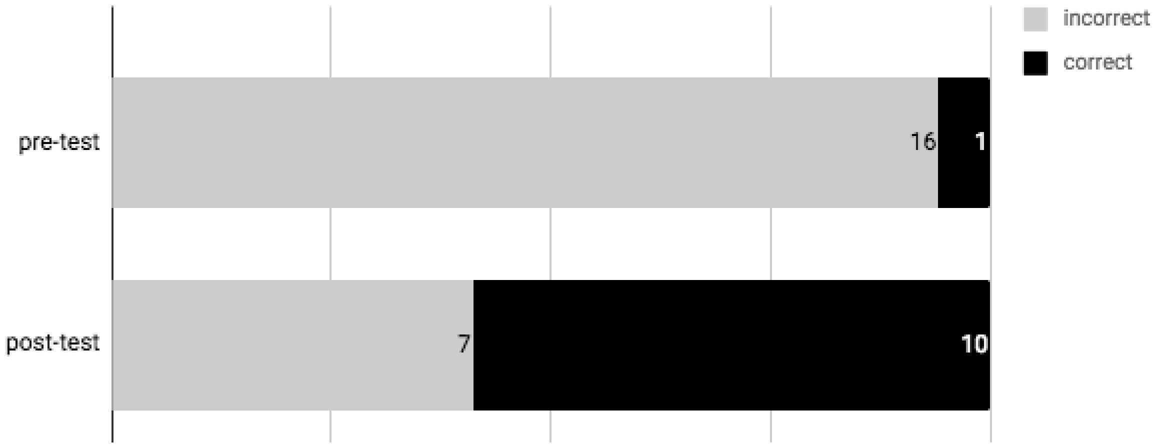


Fig. 2. Summary of answers to question 2 (own elaboration)

It can therefore be concluded that the dissection of the fish skeleton and the making of the maquette significantly contributed to the increase in students' knowledge regarding the number of fins in the fish.

Question 3: Divide the names of the fins into even and odd?

Answering the question about the even fins in the pre-test, most students did not give any answer (9 students) or answered "I do not know" (3 students). One of the students gave an incorrect answer (giving the name of the odd fin). The answers of 3 students were considered partially correct (they contained the statement that these are pectoral fins or, apart from those listed as even, also an odd one). Only 1 student correctly listed even fins. Whereas, in the post-test, 11 students gave a full correct answer, 2 students gave incomplete answers (because in addition to the listed even fins, there was also an odd one or only the pelvic fins were listed), 3 students did not give any answer and 1 student gave an incorrect answer (Tab. 2).

Analogous results were obtained in the case of the question about odd fins. In the pre-test, 9 students did not answer this question, 1 student wrote "I do not know" and 1 student wrote "this small one", which was also considered incorrect. The answers of 6 students were considered partially correct (despite being correct, they were not complete or contained a statement that these are not pectoral fins). After the dissection of the skeleton, the most frequently provided answers were partially correct (7 students) or completely correct (6 students). The partially correct answers included those which, despite their correctness, were not complete answers. Only 3 students did not answer this question and 1 student answered incorrectly (they listed pelvic, ventral and adipose fins as the odd fins) (Tab. 2).

Tab 2. Summary of answers to question 3 (own elaboration)

Names of the fins	**Test/Answer**	**Incorrect**	**Partially correct**	**Correct**
Even	***Pre-test***	*13*	*3*	*1*
	Post-test	4	2	11
Odd	***Pre-test***	*11*	*6*	*0*
	Post-test	4	7	6

Therefore, it can be concluded that in the case of the even fins, the vast majority of students achieved success and remembered their names and number, whereas in the case of the odd fins, the success was only partial. This may be due to the fact that there are more types of odd fins to remember compared with the even ones.

Question 4 in the pre-test was: Why do you think the fish has a darker color in some places?, while in the post-test the question was: In which places does the fish meat have a darker color? Why is it like that?

It turned out that the students did not notice the color of meat during the dissection. Both in the pre-test and post-test, most often students did not answer the question (10 students in the pre-test and 8 students in the post-test). However, in the post-test, there is a noticeable decrease in the number of incorrect answers, an increase in partially correct answers and even one correct answer. Partially correct answers included incomplete answers (they only indicated the place and did not explain the reason) (Tab. 3).

Tab 3. Summary of answers to question 4 (own elaboration)

Test/Answer	**Incorrect**	**Partially correct**	**Correct**
Pre-test	*16*	*1*	*0*
Post-test	11	5	1

Question 5 Give the names of other fish you know. Comparing the obtained data (Tab. 4), an increase in the number of listed fish can be seen. Before classes, students listed on average 3-4 fish species and after classes 5 species.

Tab 4. Summary of answers to question 5 (own elaboration)

Test/ Answer	0	1-2	3-4	5-9	>10
Pre-test	*1*	*5*	*3*	*6*	*2*
Post-test	2	1	5	5	4

Although during the classes the teachers did not mention fish names, the number of mentioned species increased. This is a side effect of the project; looking for information about fish dissection, the number of fins and their distribution in different species, and talking about skeleton dissection and fish which like and do not like to eat, the students incidentally expanded their knowledge of fish names. It is sometimes difficult to assess what additional information the students will learn in the project; extending the number of known fish by the students was not the intended goal of the project.

- Evaluation questionnaire regarding students' opinions about classes

In the questionnaire evaluating the classes, the students were asked 3 closed-ended questions:

1B. The classes were: very interesting/interesting/not very interesting/uninteresting

2B. The classes were: difficult/quite difficult/easy

3B. I would like to/I would not like to gut fish: watch its guts, heart, gills …

In the answer sheet to *Question 1B*, a 5-point Likert scale was used, removing the lowest point from it: *very uninteresting* due to the fact that the topic of the project was proposed by the participants and considered by them to be interesting. Most of the students considered work in the project as very interesting (11 students) or interesting (2 students). 2 students did not like the classes related to the dissection of the specimen, the same number of students did not answer this question. Therefore, it can be concluded that the classes met the expectations of the majority of students.

Question 2B The answer sheet had a 3-point scale. 7 students found the classes quite difficult and 5 students found them difficult. 3 students considered them easy and 2 students did not answer this question. It seems that the students' answers reflect the actual level of difficulty they faced during the classes. Dissecting the skeleton required precision and attention, and creating a 3D model from it required ingenuity.

Question 3B The answer sheet included 2 types of answers. Similarly to the first question (in which 11 students considered the classes very interesting), the vast majority of students (10) would like to carry out the dissection of some other specimen and 4 people would not like to do it. 3 students did not answer this question. It can therefore be concluded that the dissection of the skeleton is not an activity for all students; however, the vast majority of them do not mind such activities and would be happy to participate in them in the future.

There is a weak correlation (Spearman correlation = 0.176) between whether the students were interested in the execution of the section (question 1B) and the acknowledgment by them that independent performance of the section is difficult (question 2B). This is due to the fact that students interested in making the section - carefully and accurately prepared the skeleton of the fish. And their models were very carefully and accurately described. Therefore, it took them a lot of time and effort. Students not interested in the subject worked inaccurately and carelessly. It did not take them a long time to complete the model. However, there is a strong correlation (Spearman's correlation = 0.864) between the answer to question 1B and 3B - which is quite obvious - children who wanted this type of activity fulfilled their dreams. In contrast, there was no correlation (Spearman correlation = 0) between the difficulty of the course and the satisfaction of students.

DISCUSSION

- *Knowledge tests.* The increase in knowledge between the pre-test and post-test in questions 1 to 3 shows that by dissecting fish skeleton and making the model, students can extend their knowledge regarding the structure of the fish skeleton and the number and names of fins. Particularly noteworthy is question 1 – among people who had not drawn the skeleton in the pre-test, there was a significant progress in the final test. Answers to question 4 show that more time should be devoted to this issue while working in the project or a separate stage should be created, which will deal more closely with the internal fish structure and its consequences. While working on the project, the students also enriched their knowledge by learning about new fish species (Question 5), although this was not the main goal of the project.

The research results presented above show that the section is an effective education tool. Similar results were also obtained by other researchers (eg Vasudevan, Karthikeyan, Supriya, K., 2011) in this studies of the majority of the respondents (82.3%) felt that vivisections significantly enhanced their knowledge in animal anatomy.

- *Evaluation* Over 10 students who considered classes interesting or very interesting were interested in doing the task again even if they thought that it was quite difficult or difficult for them to complete it.

CONCLUSIONS

Taking into account the increase of knowledge of all participants of the classes regarding the skeleton structure and the increase of knowledge in the majority of students regarding the types and division of fins as well as general satisfaction of students, it seems appropriate to include this type of classes in formal education.

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Contact address

Mgr Wioleta Kopek-Putała[1], Dr. hab. Małgorzata Nodzyńska[2]

[1]Department of chemistry
University of Hradec Kralove
Rokitanského 62
500 03 Hradec Králové, CZ

[2]Department of Didactics of Natural Sciences
Pedagogical University of Cracow
Podchorążych 2
30-084 Kraków, PL

MISCONCEPTIONS ABOUT BIRDS´ DIMENSIONS (STARTING POINT FOR PROJECT BASED ACTIVITY)

SCHUBERTOVÁ Romana, KVIATKOVÁ Tatiana, MALINA Radovan

Abstract

The study of pupils´ misconception in the field of zoology is actual topic for researches in science education. There is a positive correlation between the pupils´ attitudes and knowledge about certain groups of animals and therefore the increase of their knowledge structure can positively influence their pro-environmental attitudes. The misconceptions of pupils about birds are examined in terms of their internal body construction, habitus, migration, classification and so on. This paper presents a pupils´ perception of the dimension (wingspan) in the case of selected bird species. Results of the research show that perception of dimensions is underestimated in all investigated species, which may create an appropriate cognitive conflict for pupils´ inquiry of this group of animals by making a project.

Key words

Project based Learning, Models in Science, Misconceptions, Science Education,

INTRODUCTION

One of the numerous goals of science education is to develop understanding of set of „big ideas“. Big ideas of science contain also the one about diversity of organisms: „The diversity of organisms, living and extinct, is result of evolution“ (Harlen, 2010).

Not only understanding of selection process, but also knowledge about animal or plant species, their identification and life history, has been target as a fundamental aspect for learning and understanding of biodiversity (Lindemann-Mathies 2002; Randler & Bogner 2002). The ability of pupils to identify bird species was investigated by Prokop and Rodák (2009). They manipulated bird growth habit and bird song to test Slovakian pupils´ abilities to identify native birds. Use of slides alone was less effective than simultaneous use of acoustic signals when teaching pupils about birds. Randler and Bogner (2002) examined effect of using different teaching methods for ability to identify birds. Experimental group of pupils was learned by hands-on and learner-centered environment. The other, control group, received a teacher-centered demonstration using a slide presentation. Groups were dealing with the same species.

In the case of 14 species there was no significant difference between groups. It is interesting that there was significant difference in repeated experiment with 6 species. As a conclusion, they suggest to reduce number of species and to use „modern“ instructional approaches. During the teaching species identification, the names of the species should be explained to aid learning and understanding (Randler 2008). It is also possible to use outdoor ecology education, but it deal with rather immobile taxonomic groups, such as a plants or invertebrates (Killerman 1998) because amphibians (or mammals, birds) are sometimes difficult to observe under natural conditions. Further, outdoor education could be, in this cases, enhanced by previous learning within the classroom to prevent students from a cognitive load and from novelty effects (Falk 1983; Sweller et al. 1998).

In the field of science education, researchers are in recent years focused on mapping and studying of misconceptions. Conceptions, developed by students themselves, are often far from reality, making troubles for later years of learning. Misconceptions about birds are widely examined in few areas – **classification** (e.g. bats are birds because they can fly), **characteristics** (e.g. birds have teeth in their beaks that help tear food apart), **behavior** (e.g. birds migrate only to warmer regions in order to avoid freezing), **interaction with people** (e.g. if a person touches the nest of the bird, birds will never come back to the nest) (Cardac 2009). They can be connected with anthropomorphical and teleological reasoning of the children (Prokop et al. 2007). As far as we know, there are not researches, studying pupils´ misconceptions about birds from a dimensional point of view, even though it occurs as a common problem among university students and also adults.

It is known that books and instruction materials can reinforce misconceptions too (Coll & Treagust 2001). We can find examples of "one size" birds of different species also in recently used biology textbooks, which can support pupils´ misconceptions about dimensions of them.

GOALS OF RESEARCH AND METHODS

Research of pupils´ ideas about dimensions of wingspan is part of a wider research work, realized by approach - design based research. On the one side, it includes theoretical and practical goals bringing new theoretical knowledge to the theory of science education, on the other side research is solving actual problems of science education by creating a useful artifact. As a problem in recent education we can see low motivation of pupils to learn about specific species (caused also by easy availability of information), and misconceptions of them, because most of the species are observable just through the pictures. Even though pictures don´t have a potential to convey the idea about dimension, we can predict problems of pupils with ideas about dimensions of wingspan. In accordance with design based research, the goal of our wider research is to:

- Explore ideas of pupils about dimension of wingspan in the case of most known species.
- Design teaching practice, which can corrects misconceptions of pupils about dimensions of birds.

In the context of the goal mentioned before, we have identified following research questions and tried to answer them in this paper:

- What are the ideas of 5th grade pupils about dimensions of selected bird species?
- Is there difference between boys and girls in the case of perception of bird dimensions?
- Is there relationship between real size of birds and pupils´ ideas about dimension of them?

Participants

A total of 160 pupils from 5 elementary schools participated in this study. Pupils were 10 – 11 year old (grade 5), with 96 girls and 67 boys. Research has been carried out before teaching about birds, because we assume that pupils know chosen species from everyday life and previous education.

Data collection and analysis process

We used a table with the names of each species to collect the data, while the pupils had wooden or paper rulers with length of 1 meter. The choice of species took into account the ability of pupils to concentrate on the task – we assumed that more of the species can cause pupils to ignore the task and subsequently distortion of the data. Six well-known species were selected, including small, medium and large species and also predators and owls:

- Common Buzzard *(Buteo buteo)*, Northern Goshawk *(Accipiter gentilis)*, Tawny Owl *(Strix aluco)*, Eurasian Jay *(Garrulus glandarius)*, Great Spotted Woodpecker *(Dendrocopos major)*, Great Tit *(Parus major)*.

Pupils were instructed to imagine the wingspan and then help with ruler to express its length. They were warned that the length of the wingspan can be even greater than the length of the ruler itself.

We examined "the mistakes" of pupils and expressed them like difference from real average value of the wingspan, which can acquire both positive and negative values. The difference in perception of the wingspan was then re-labeled (to make the results more comparable between the species) by formula:

(value of pupil – real value) × 100 / real value

This gave us an insight into the percentage difference between pupils´ view and real wingspan in the case of each species. Data didn´t follow a normal distribution, so Wilcoxon nonparametric test was used.

RESULTS

Differences in pupils´ perceptions and real wingspan are shown in Table 1. It is obvious that pupils predominantly underestimate dimension of birds (median of the assumed and real value is in the case of each species negative). Underestimation is not uniform for all species. Large standard deviations, as well as large minimum and maximum values (see Figure 1), indicate that the perceptions are inconsistent inside the child population. Results do not distinguish between boys and girls (statistically significant difference $p = 0,004$ was reflected just in the perception of Great Tit dimension, and only after removing of outliers).

Table 1 Comparison of real average value of wingspan and perception of pupils

	real average value (cm)	mean difference ± standard deviation (cm)	median (cm)
Common Buzzard	120,5	-51,19 ± 44,31	-56,00
Northern Goshawk	110	-31,64 ± 41,00	-30,00
Tawny Owl	99	-41,7 ± 29,42	-49,00
Eurasian Jay	55	-25,17 ± 16,91	-29,5
Great Spotted Woodpecker	36	0,69 ± 21,16	-1,00
Great Tit	24	-4,45 ± 12,14	-8,00

Figure 1 shows the distribution of perceptions within the research sample in the sense of the percentage difference between pupils´ view and real wingspan. Pupils hold most realistic ideas about smaller species – Great Tit and Great Spotted Woodpecker. This corresponds with results of Prokop and Rodák (2009) that these species are visually very easy identified by pupils. In the case of Great Spotted Woodpecker, mean and median is almost identical with real value.

However, in the case of jay, goshawk and buzzard – pupils underestimate values about half of the real length of wingspan.

There is no significant relationship between underestimating of pupils and size of the bird, but we can see that pupils distinguish between predators and other birds. It looks like they imagine predators as a bigger birds (mean pupils´ value in the case of goshawk is 78,36 cm and for buzzard it is 69,31 cm). The jay is not one of the smallest birds, but kids underestimated it most of all (visible on value of 75% quartile), maybe because it is not predator. At the same time perception of pupils about jay is most consistent inside of sample. To confirm the indications that predators are automatically bigger from the pupils´ point of view, we need to know exactly which species do pupils distinguish as predators.

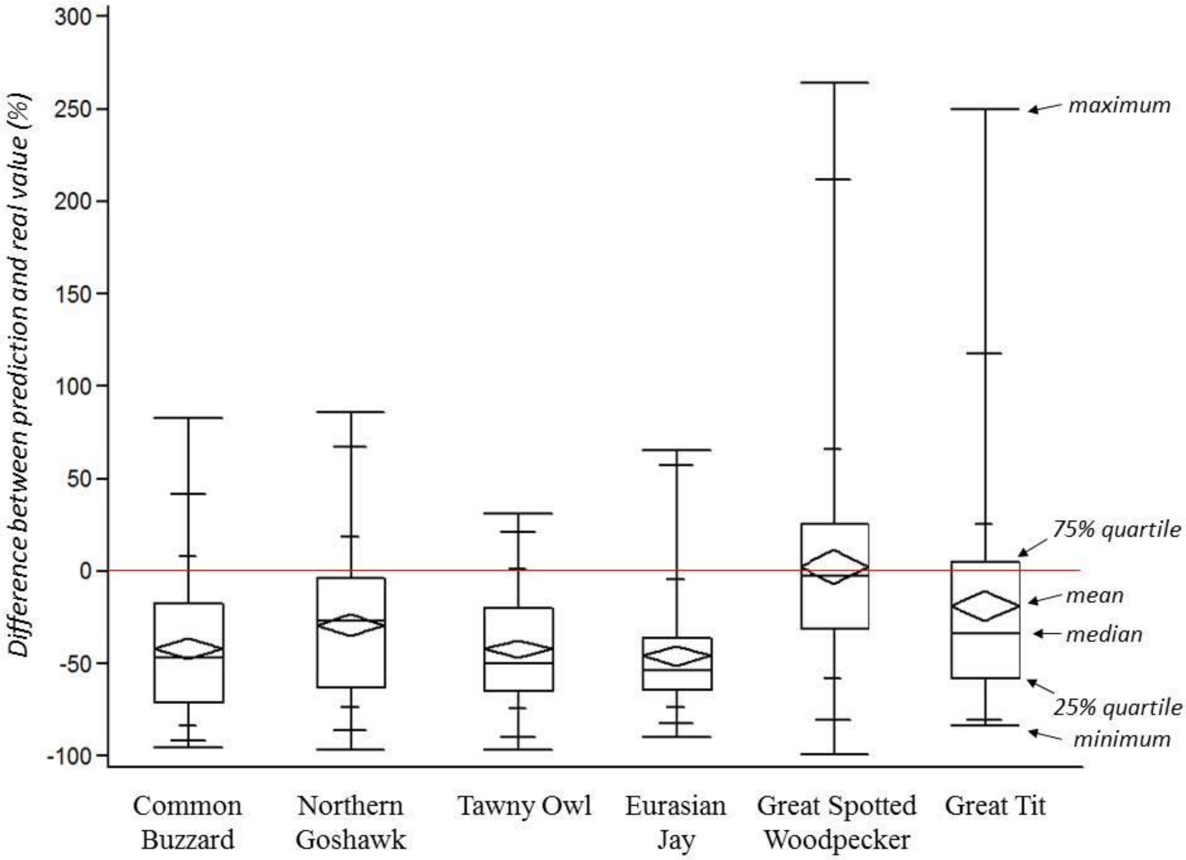

Figure 1 Distribution of difference between prediction and real value in research sample.

EDUCATIONAL IMPLICATIONS AND DISCUSSION

Presented results confirm the assumptions about the incorrect pupils´ perception of birds´ dimension. These misconceptions can be of major importance for the creation of teaching practice (educational activities). In fact it is difficult to provoke cognitive conflict inside the topics about species, which is both – about the whole group of organisms and allows learning about specific species too. Proposed activity, following presented research, has this potential. It is now in the process of iterative optimization. In project-based activity pupils easily identify differences in their perception of birds´ dimensions, which leads them to solve this problem by creating the paper models of most known species. Activity includes more steps:

- Group brainstorming about the characters, by which we can identify individual species. Pupils usually designate color, body shape, song, shape of the beak or feet, and almost always also size appears. Teacher emphasizes the size as an interesting factor and pupils discuss in the groups – why it can be difficult to determine the size of specimen.
- Pupils individually fill the table of predictions about dimensions in the case of some species and compare the assumptions within the group. They are discussing how to solve a problem with misconceptions of people about the size of birds. At this point, groups are sometimes offering bizarre ideas – such as shrinking an individual and bringing it to the class, but also usable ideas of making the models of them. We can use this ideas in the proposal of project and make the project come from pupils themselves.
- Pupils in the groups create paper models of birds in their real dimensions (generally 2 species for one group, bigger and smaller one). They work with the silhouettes and information about the species, because they will present them when completing the product.
- The final product is a set of paper models that can be attached to the walls of the corridor. They can be also hanging from the roof of corridor (Figure 2). Product can be modified with regard to pupils´ needs and ideas – e.g. supplemented with bags filled with gravel, representing the weight of species. Or they can be colored according to the color of the individual or containing the QR code with the voice sample.

Figure 2 Product of university students´ project about bird dimensions (left, author) and pupils´ project from elementary school of Juraj Fándly in Sereď (right, Lucia Paulenková)

Activity contains all elements of project-based learning according to Gudjons (1986) and corresponds with the inductive approach according to Prince and Felder (2006, 2007). It is target oriented and highly interdisciplinary – in addition to biological knowledge, e.g. the concepts of axial symmetry and center of gravity are developed.

It also corresponds to results of Cardac (2009), that information about animal kingdom must be concrete. If concrete information cannot be presented, educational techniques, such a models, should be used to make information more concrete in educational environment – using birds´ model in the classroom may obtain multiple advantages. Cardac (2009) also encourages to conduct scientific projects with birds to schools.

CONCLUSIONS

In this paper we tried to highlight the issue, which is not overly discussed in the field of biological education. We expect that problems with perception of object dimensions can not only influence attitudes of pupils to organisms, but also create a suitable situation (cognitive conflict) to motivate pupils to learn about species. Pupils themselves can see, that their perceptions differ a lot. Proposed project-based activity is like “two shots with one stone”. It is trying to solve problem with pupils´ motivation to learn about bird species and also a problem with perception of dimensions. As we can see on the base of results of this research, pupils´ perception of birds´ length of wingspan is too far from reality, in some cases underestimated more than 50% of real value.

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Contact address

Mgr. Romana Schubertová, PhD., Mgr. Radovan Malina, PhD., Bc. Tatiana Kviatková

Department of biology and ecology
Faculty of natural sciences
Matej Bel University
Tajovského 40
Banská Bystrica
e-mail: romana.schubertova@umb.sk, Radovan.Malina@umb.sk,
tatiana.kviatkova@studenti.umb.sk

INFLUENCE OF EXCURSION IN THE BREWERY ON THE KNOWLEDGE OF STUDENTS AT THE SECONDARY VOCATIONAL SCHOOL

ZÁHOŘOVÁ Karolína

Abstract

The topic of microbiology and technology using microorganisms is predominantly abstract and not generally attractive and popular for students. Presented research is focused on influence of the excursion to the knowledge of the students of the secondary vocational school. The effectiveness of the excursion was evaluated on the basis of a comparison of pretest and posttest results. A fundamental change and substantial increase in student knowledge has been shown (from 25.1 % to 74.5 % of total score). The results of research show a clear positive influence of the excursion on students' knowledge and therefore the excursion can be recommended as an adequate substitution of classroom teaching.

Key words

Biology, Chemistry, Outdoor Education, Practical Work in Science, Secondary School

INTRODUCTION

Excursion is a form of teaching serving as a supplement to classical teaching. Unlike classical lesson it has potential to get students more involved, which increases their activity. Excursion also serves as a motivation. A lot of authors deal with this topic of motivation of students and increase of their interest in connection with excursion (Čapek, 2015; Prokop, Tuncer a Kvasničák, 2007; Janštová, 2015; Zoldosová, Prokop, 2006, Drissner, Haase, Hille, 2010; Kissi, Dressmann, 2017). Some authors also deal with the influence of excursion on the students´ opinion - (Sellmann, Bogner, 2012; Kossack, Bogner, 2011).

Importance of excursions on the increase of knowledge is also in the centre of interest. Some authors confirm it (Hamilton, Ekeke, 2007; Bogner, 1998, 2002; Přibylová, 2014; Kissi a Dressmann, 2017; Easton, Gilburn, 2011; Drissner, Hasse, Wittig, Hille, 2013), others for example Čábelová (2008) Carlin (1999) question the increase of knowledge of the students who took part in the excursion in comparison with students who had an ordinary lesson.

EXCURSION TO THE BREWERY

This particular part of the excursion took part in Prague in the brewery ‘’U Fleku’’ Kremencova street. Each student got a working list before the beginning. Guided tour with an internal brewery worker was settled in the brewery. Students watched a short movie about history of brewery industry in Prague, history of brewery U Fleku and about beer production. There were presented all information necessary to fill the working list.

After the movie the students could look at the ingredients needed for beer production and they heard a short comment about ingredients its processing and quality testing. Then they saw the establishment with stainless steel tanks for beer fermentation, brew, cooling sink, and fermentation tanks in spilka. Example of brewery yeast was presented and fermentation procedure including exact description of entering and leaving substances was explained. Students were introduced to an elementary terminology in a brewery industry field.

TESTING OF STUDENTS

Testing was done by the same test, which was given to the same group of students before the excursion as pretest (*n = 36)* and then after the excursion as posttest (*n = 36).* The aim was to find out how the students will be successful in solution of questions and what influence the excursion itself would have on the knowledge of the students. The test has 9 questions, students fulfilled it in printed form and returned it immediately. So the return was in both cases 100 %.

Questions 1,2,8 and 9 were focused on microorganisms. The first two questions were strictly theoretical. They concerned the taxonomy and general characteristics of yeast. Questions three to seven were focused on the technological processes of beer production - fermentation, input and output of the fermentation process, brewing terminology. Students could get a certain amount of points for the correct resolution of each question, depending on the difficulty (see tab.1).

Tab.1 Evaluation of questions, Záhořová

question Nr.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**total**
max. number of points	5	2	4	1	11	10	7	1	1	42

RESULTS OF EVALUATION

Final results of pretest and posttest are given in Fig 1. It shows that the relative number of obtained points in posttest increased in comparison with pretest for about 50 %.

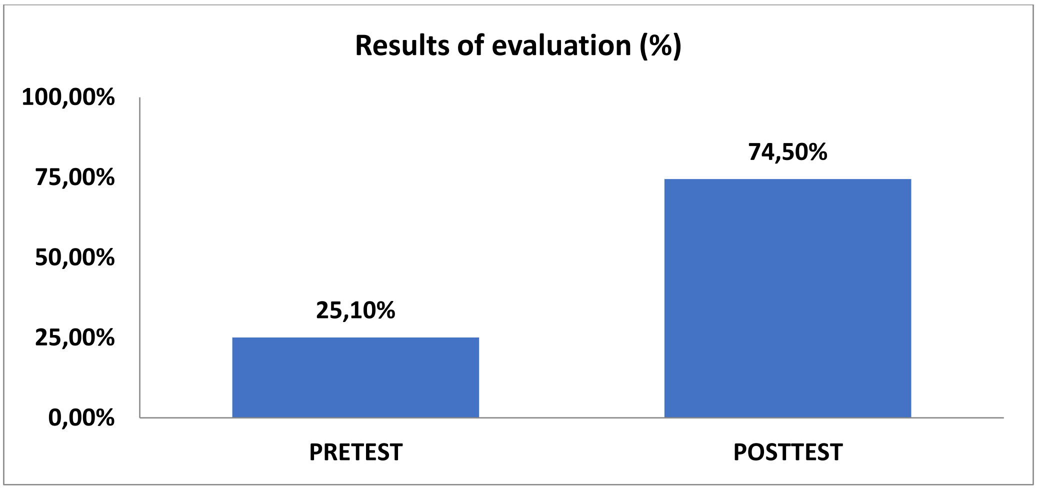

Fig. 1 Comparison of test results in percentage for entire sample (36 respondents), source: Záhořová, 2017.

Results of point score of pretest and posttest of individual students are given in Fig 2. Number of point obtained by students in pretest was between 1 and 23 points. Success rate of students in posttest given in point was significantly higher between 30 and 40 points.

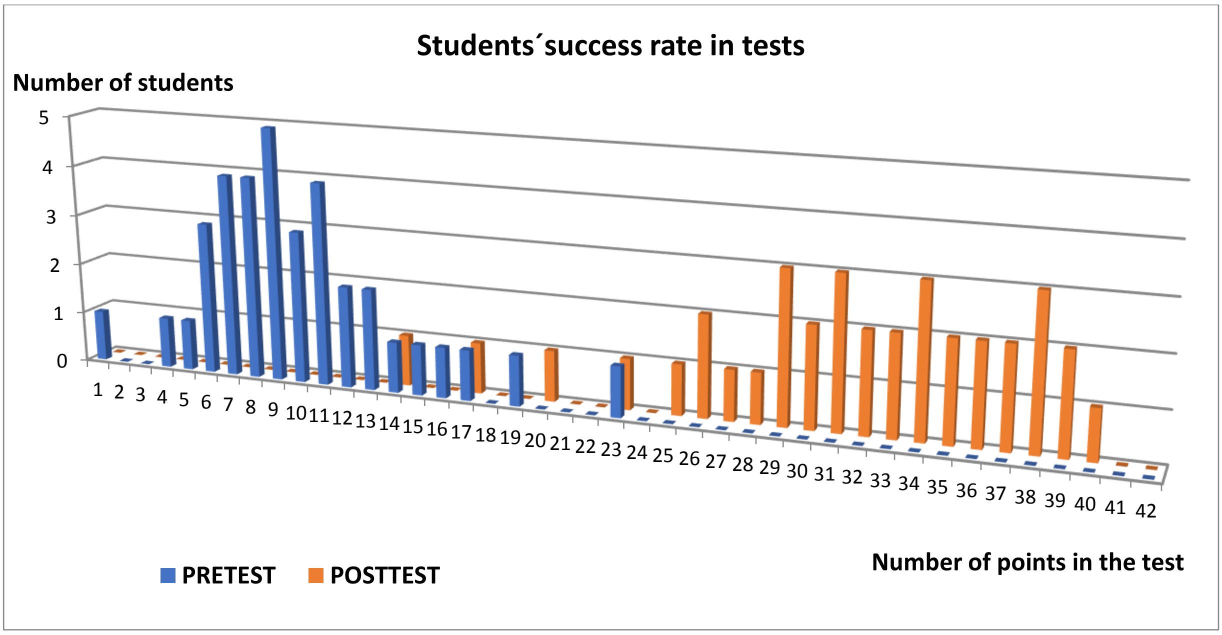

Fig. 2 Frequency_of students according to point score obtained in pretest and posttest, source: Záhořová, 2017.

Evaluation of individual questions in the tests

Success rate in percentage on individual questions in pretest and posttest can be seen in Fig 3.

There we can clearly see, how the success rate changed at individual questions and what influence this excursion had on the knowledge of students. Decrease of knowledge did not appear at any question. The smallest difference in results of pretest and posttest is at question 1 and 2. High output knowledge obtained during theoretical education before the excursion can be seen. The excursion itself contributed only a little, because it was not aimed to its development.

Question 1 (adding basic concept to the text) was not a problem for majority of students, even if maximum score received only 5 students (14 % of respondents). Students made the most mistakes at the problem of yeast multiplication. While 17 students (47 %) choose the correct variation (division), 19 students (53 %) false variation (bisection). 8 students achieved maximal score (22 %) in posttest, which can certainly be considered as improvement. However in total as a group students did not show almost any point increase. It is interesting that the students correctly answered how the yeast multiply, but made mistakes in questions aimed to systematic biology (placement of yeast among eukaryote and into the kingdom of fungi).

In question 2 students had to draw and describe schema cell of yeast. All 36 students (100 %) draw cell correctly, but only 4 of them (11 %) managed at least partly to describe it. Three students draw and described the core, one student (3 %) core, cytoplasmic membrane and cell wall. Results of the posttest were similar at this question. 100 % of students draw correctly cell, 5 of them managed to describe it partly (14 %). The following analysis showed that among these 5 students there were 4 who had the correct answer already in the pretest.

Question 3 required the choice from offered possibilities the substances entering the process of beer production, (water, polysaccharides – starch) and substances of output (ethanol, carbon dioxide).

8 students (22 %) did not answer at all in the pretest or answered incorrectly and obtained 0 points. Students, who tried to answer this question chose various options and combinations. For example as matters entering the process of beer production often chose monosacharides or methanol and ethanol. It is interesting, that these compounds were often chosen as an output together with oxygen. It looked like the students are have awareness about fermentation process that they know which substances play role in this process but they do not know how and where and therefore they randomly tipped. Great improvement was noticed in posttest. 28 students (78

%) answered correctly and I consider it at this very problematic question in pretest as a great success. I thing, that the excursion had a great impact on understanding of fermentation process.

In question 4 students should add into the sentence "Beer fermentation takes place in …". There were given 5 choices (tank, barrel, spilka, tub). Only three students from 36 (8 %) answered correctly in pretest. All students (100 %) answered correctly in posttest.

Question 5 dealt with beer production. Students had to correct mistakes in the text. Fifteen students (42 %) did not give any answer. The highest number of points, were 3 points from 11 possible. The posttest was answered by all students and the number of achieved points was from 2 to 9. Nobody had maximal number of points.

In the question 6 the students had to put into order words (bottling, cooling, maturation, mashing, malting, cooking, rinsing, expedition, fermentation, filtration) during beer production. There was noticed a significant improvement in posttest compared to pretest. 28 from 36 students answered correctly (78 %).

Seventh question aimed to brewery terminology. Students had to link brewery terms (draught beer, mash, wort, lager, young beer, old beer, grain) with the correct definition. During the pretest only one from 36 students achieved full amount of points (3 %) and 7 students 0 points (19 %). The most of students achieved 3 points. It is interesting that they achieved those three points for absolutely different answers. This question was hard for the students also in the posttest. Full amount of points obtained more than a half of students (15, 42 %).

Question 8 was "What role bacteria play in beer production?" Expected answer was "none" or "they cause beer depreciation". In the pretest 34 students (94 %) did not answer this question at all. Only 2 students (6 %) gave the correct answer. In the posttest 31 students (86 %) answered correctly.

Question 9 required basic knowledge from biology lessons and ordinary live. Students had to give an example of another food made with use of yeast like beer. Pretest showed that students do not have this knowledge. Only 3 students (8 %) gave correct answer, 33 students (92 %) did not answer at all. In the posttest there were 30 correct answers (83 %). It is important to say that the significant improvement was in connection of brewery worker lecture, who repeatedly mentioned the significance of yeast.

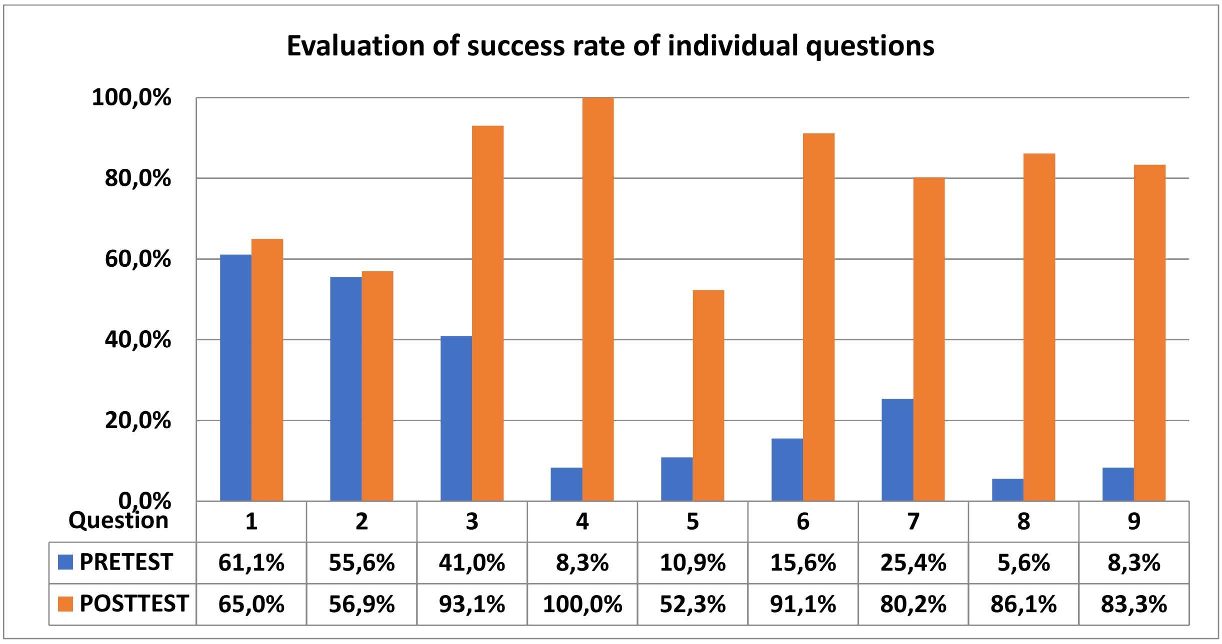

Fig. 3 Comparison of the average percentage success of students in individual questions, source: Záhořová, 2017.

Comparison the results of questions 1,2,8 and 9 focusing on microorganisms with questions 3,4,5,6,7 focusing on technological processes of beer production shows a positive increase in student success in both categories of questions. Nevertheless, in the category of questions about brewing technology, there was a significantly greater difference between the success rate of pretest and posttest (Fig.4).

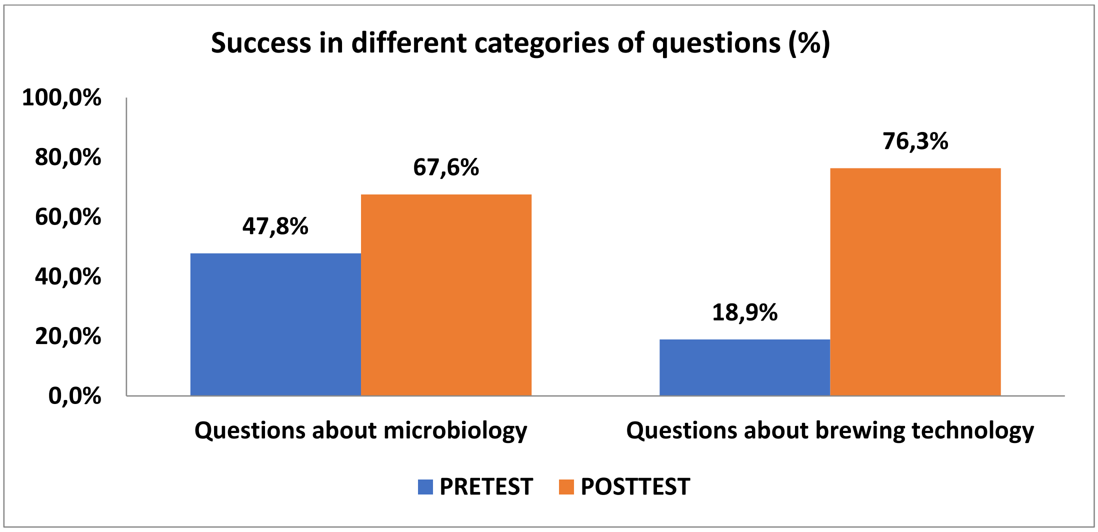

Fig. 4 Comparison of students' average percentage success in questions about microbiology and brewing technology, source: Záhořová, 2017

DISCUSSION AND CONCLUSION

Main aim of the research was to find out whether the excursion as an alternative form of education will have an influence on knowledge of the secondary vocational school students. Study of bacteria and microorganisms and technology using microorganisms is for students hard and not attractive because of its abstractness and knowledge of this topic corresponds with it. It is important for the teacher to find out how to motivate the students and increase the efficiency of education. There are offered several ways (Janštová, Rusek, 2015): inquiry-based education and practical exercise (focused on microbiology see Pavlasová, 2016) work with informational and communicational technologies, excursions, summer camps, projects (Kadlecová, Pavlasová, 2016) competitions and olympiads. The common denominator of such actions is connection of lessons and praxes. The students in the excursion described here could see specific going at specific location. They could touch and smell everything, make pictures and ask specialist direct questions.

Results of student testing show clear positive influence of excursion on their knowledge, and it can supplement common teaching in the class. It can be recommended as a suitable form for teaching microbiological topics in biology and chemistry.

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Contact address

Mgr. Karolína Záhořová

Katedra biologie a environmentálních studií
Pedagogická fakulta,
Univerzita Karlova
M. Rettigové 4
116 39 Praha 1
e-mail: zahorova8@seznam.cz

HOW PRIMARY SCHOOL TEACHERS PERCEIVE INTEGRATED THEMATIC INSTRUCTION

BORTLÍKOVÁ Monika, VÁLEK Jan

Abstract

The integrated thematic instructions are used by science teachers as a form of motivation at primary schools. This form of motivation is quite attractive for primary school students. The primary school students cooperate with the teacher during this type of teaching methods. The teachers' view of the given teaching method is individual and influenced by many specific external factors. Advancement of this teaching method depends not only on teachers´ creativity but also on their inspiration. Teachers should be prepared to integrate new information into their teaching and learning practices. The integrated thematic instruction is focused on various aspects of educational process and should improve soft skills of primary school students. They subconsciously acquire skills of constructive discussion, designing solutions, revision of results, cooperative problem solving, argumentation and many others. Primary school students also become more aware of their responsibilities. It is proved by their enthusiasm for integrating the problem solving model into their studies. The paper is focuses on analysis of the teachers´ attitude to the integrated thematic instruction. The study is based on a semantic differential technique. The findings of this study suggest that integrated thematic instruction can be effective in improving attitudes towards science subjects and building personal skills of primary school students.

Key words

Motivation, teaching methods in science, teaching practices, investigation

INTRODUCTION

Integrated thematic instruction is based on the curricula. There is the emphasis on the integration of all disciplines to the learning process. Integrated thematic teaching is perceived as a consolidation of curriculum. It allows a more effective achievement of learning objectives (Šindelková, 2017). Primary school students present their learning experiences that are based in real-world application and structured to encourage higher-order learning and the development of the critical thinking (Ross & Olsen, 1993).

LITERATURE BACKGROUND

„The goal of the integrated thematic instruction model and the innate drive of the human mind-is mastery. That is, the learner understands the skill or concept, knows how to apply it in the real world in similar (but varying) circumstances, and has incorporated it into a mental program. Such mastery or competence is at the heart of positive self-concept, of a sense of empowerment and ability to direct one's life, and it is consistent with the brain's innate search for meaning." (Kovalik & Olsen 1994, p. 11-12)

During integrated thematic instruction students use all available materials, knowledge and skills from various school subjects. Students usually work in groups and the teacher organizes the work during the integrated thematic instruction individually, selects adequate materials and works with them. Such co-operation appears to be one of the most important features (Rusek & Dlabola, 2013).

The school plays a key role in the creation of pupils' relationships to education, particularly in understanding the meaningfulness of education for their lives. At the same time, it is also required in our society that the educational outcomes be applicable in practical life. Integrated thematic instruction has the potential to influence students' attitudes toward science. Teachers deal with this situation in different ways. They use various methods and approaches which can motivate students and improve their attitude towards science. One of these methods is integrated thematic instruction (Hassan, 2011).

Students should work effectively during educational process. Teachers have very difficult position. They have to deal with the following aspects:

- Work with proposed topic
- Team building
- Seeking for suitable materials
- Seeking for suitable methods
- Time management
- Product oriented activities
- Realisation of Public Relations

In all the mentioned aspects the teachers have an important role. They can organise own approach by introductions, by consultations, by evaluation of the students´ ideas etc. In general school is a place of the co-operation and the encounter of these groups in the teaching-learning process (Bílek, 2015).

Motivation of primary school students to science is not easy for teachers. They have many different approaches how to motivate primary school students toward science. These approaches should include activities with project elements, planning and management activities (Bílková, 2015). In general, learning should be relevant (Lindner, 2014). The term “relevance” in science education is widespread and multi-faceted. Relevance in science education is used in various ways and is often used synonymously with other educational concepts. It has already been made several suggestions for conceptualising and operationalising the term in science education. These suggestions intend to differentiate between a perception of relevance which merely overlaps students’ interests and a perspective which contains other areas of relevance (Stuckey, 2013).

That is not only in level of motivation (how much motivation), but also in the orientation of that motivation (what type of motivation). Orientation of motivation concerns the underlying attitudes and goals that give rise to action. As an example, a primary school student can be highly motivated to do exercise in workbook out of curiosity and interest or, alternatively, because he or she wants to procure the approval of a teacher (Ryan, 2000). A primary school student could be motivated to learn a new set of skills because he or she understands their potential utility. Science teachers have a difficult role in the teaching-learning process. They should motivated primary school students in the positive way (for example by using integrated thematic instruction).

Teachers can use some powerful tools which can increase students’ motivation as well as their interest in Science (practical courses, experiments, inquiry, projects or field trips, summer camps). It is possible to use activating methods in science subjects. Their use is consistent with the content knowledge and additional core competencies (Gabriel & Rusek, 2014). As in different matters, teachers’ methodical support is critical. The change needs to stem from the teachers as there is no curricular change which could make them alter their educational approach. Quite a lot of teachers feel it is important to raise their students’ awareness in Science rather than just go through the subject matter. The above described methods and educational forms may soon be adapted more widely in Czech schools (Janštová & Rusek, 2015).

RESEARCH SURVEY

The aim of the survey was - To find out how the primary school teachers perceive integrated thematic instruction. The respondents were all the primary school teachers at the second level of the primary school. We send 68 e-mails to primary school teachers in the area of South Moravia. All teachers work at primary schools. These primary schools cooperate with Faculty of Education (Masaryk University in Brno) during student teaching practices. These primary schools are called "Faculty primary schools". All respondents (teachers) work at primary schools more than 5 years. They coordinate university students on the teaching practices. They participate in the training of university students. We received 47 completed questionnaires (it is more than 60 % returning the questionnaires), out of which 19 were men and 28 women. The teachers teach science subjects (chemistry, physic, biology, geology), so it is reason why is the number of men so high.

To examine the attitudes of respondents, we chose the semantic differential (Bauer, 2008; Kubiatko, 2016; Hsu, 2000). Semantic differential is designed to measure the connotative meaning of concepts (the attitude towards the given object). Semantic differential has 3 factors, which are tested (evaluation, potency, activity). These factors have a special scale of positive and negative adjectives. Respondent should choose adjective in seven points scale. This scale is for each pair of adjectives (one is positive and second is negative). The respondents choose position on a scale between two polar adjectives. We chose 5 pairs of two specific adjectives for every factor.

Semantic differential factors used in survey:

- **Factor Evaluation**
  (Good – Bad; Valuable – Worthless; Wild – Quiet; Clear – Unclear; Near – Far)
- **Factor Potency**
  (Big – Small; Strong – Weak; Deep – Shallow; Long – Short; Wide – Narrow)
- **Factor Activity**
  (Heavy – Light; Young – Old; Hot – Cold; Active – Passive; Fast – Slow)

For calculations, we assigned the number 1 for the first of the pair, the second one for the pair number 7. In this case, the lower the value, the more we prefer the first word from the pair, the higher the value, the more the second word from the pair (based on a 7-degree scale and designate 1 = positive and 7 = negative).

Table 1 Semantic differential (research of attitudes of primary school teachers to integrated thematic instruction), source: author's own research.

Term	Evaluation	Potency	Activity
Integrated thematic instruction	2.27	2.31	2.49
Motivation of pupils during integrated thematic instruction	2.52	2.59	2.72
Timing of the integrated thematic instruction	4.03	2.96	3.50
Usability of the integrated thematic instruction in the lessons with pupils	2.44	2.74	2.74
Interdisciplinary relations in the integrated thematic instruction	2.36	2.47	2.88

Values in Table 1 for both tested terms are quite close, so the respondents perceive them very similarly and positively with regard to the items of the questionnaire. This is confirmed by the values in Figure 1, where the only significant deviation is the timing of the integrated thematic instruction. This point is for primary school teachers not in positive numbers (evaluation 4.03; potency 2.96; activity 3.50). Teacher spent a lot of time for preparation lessons and experiments. So they do not have an enough time for using other teaching and learning methods.

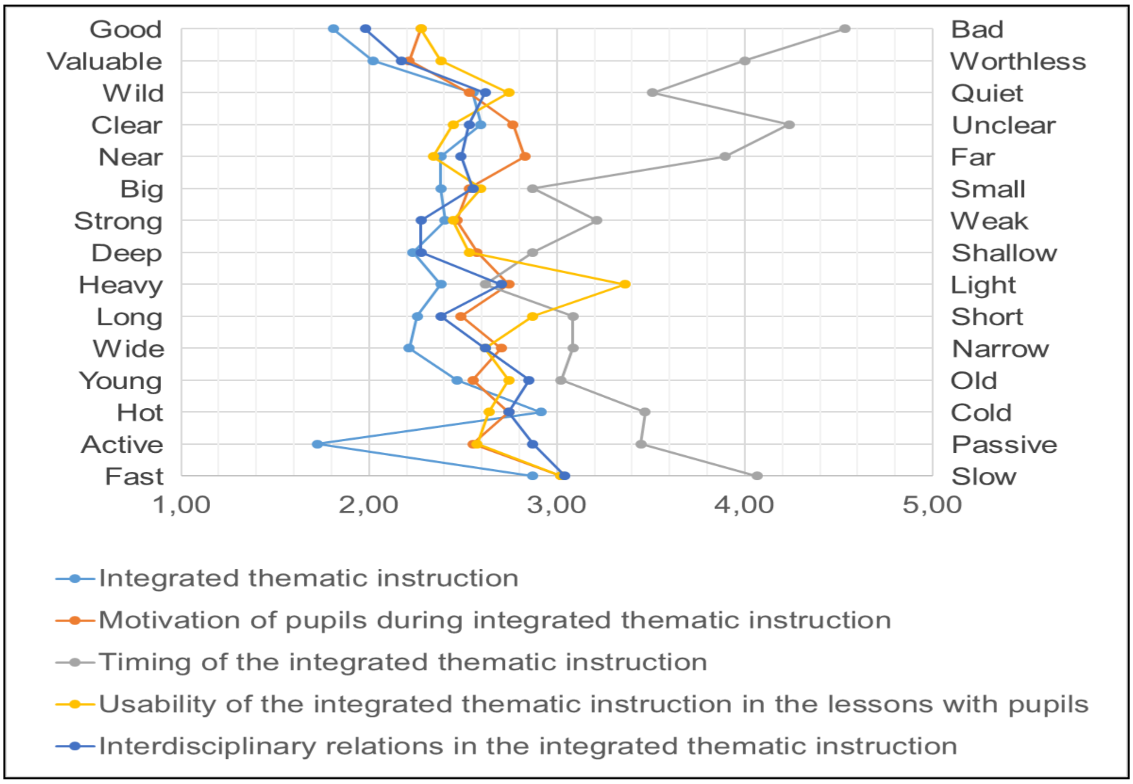

Figure 1 Results of respondents' answers, source - author's own research.

The primary school teachers have positive attitudes towards integrated thematic instruction. In the Figure 1 we see 5 topics of the questions from the questioner. They know integrated thematic instruction and they use it with their pupils in the science subjects. The motivation of pupils during integrated thematic instruction is also in a positive area. Experiments are used as a good option of motivation. Teachers have to prepare effective experiment. Teachers see timing of the integrated thematic instruction very negatively, evaluation 4.03; potency 2.96; activity 3.50 (especially preparation of materials and also time for the lessons). Timing in the school system is very difficult and also in special methods too.

CONCLUSION

The primary school teachers perceive integrated thematic instruction in a positive way. Their role in the education process is absolutely necessary so they have a strong opinion to the different teaching methods. Timing of the integrated thematic instruction is very difficult for the teachers. They have problems with preparation of this method. It is demanding activity for them. Integrated thematic instruction is a very good motivation in the science subjects at primary schools and also it is an attractive way of teaching and especially learning for pupils.

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Contact address

PhDr. Monika Bortlíková, PhDr. Jan Válek, Ph.D.

Katedra fyziky, chemie a odborného vzdělávání
Pedagogická fakulta,
Masarykova univerzita
Poříčí 7
603 00 Brno
e-mail: sindelkova@ped.muni.cz, valek@ped.muni.cz

THE LIST OF AUTHORS

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