MODERN SCIENCE
TEACHING AND LEARNING

editor

Bartłomiej Zyśk

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INTRODUCTION

In the modern teaching and learning process one should aim to apply the process of scientific cognition in school education, where students stop “role-playing” scientists and genuinely become them. Thanks to such an approach, students learn critical and creative thinking, as well as independent hypotheses formation. They also apply research methods, those close to scientists, and cultivate their science skills. The main teaching method for biology students should be ‘scietific inquiry’- a process requiring problem diagnosis, critical analysis of observation and experiment assumptions, finding alternative solutions, research planning, hypotheses testing, information research, model constructing, peer discussion and the ability to form coherent arguments.

At present, science and the teaching and learning process encounter many problems, especially those in the cognitive and pragmatic sphere, relating to the knowledge of facts and processes, as well as the understanding of scientific concepts.

This paper consists of a variety of possible teaching solutions mainly based on own experience and on conducted studies. The authors of articles are most often science teacher at various levels of education and from different countries. Articles presented in this paper show how knowledge and skills used in everyday life may be applied in the classroom. The diversity of topics discussed by the authors show how one can convey information in an interesting way, both for the student and teacher. We hope that these lesson examples will inspire teachers who have problems with mobilization and concentration of students in the classroom and will help interest students in the topic being covered.

This year as well as the last, have brought additional difficulties for teachers and students, due to the Coronavirus. Articles presented in this paper show how to overcome obstacles in such unfavorable conditions. It is advised to try more mobilizing teaching methods when introducing new and often more difficult topics and to execute the curriculum in an interesting manner.

Bartłomiej Zyśk

INTEGRATED TEACHING IN SECONDARY SCHOOLS IN THE CZECH REPUBLIC

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Abstract

Integrated teaching is teaching in which the educational contents of subjects are interconnected, while the integrated educational content follows the goals of all integrated subjects (Rakoušová, 2011). It implements interdisciplinary relationships and connects theoretical and practical activities (Průcha et al., 2013). In our research we decided to find out: What do secondary school teachers think about integrated teaching? Are they implementing integrated teaching into their lessons and if so in which form? Or if they do not then why? We collected data by an online questionnaire. An e-mail with a request to join the survey was send to all secondary schools in the Czech Republic. Data was collected from December 2019 to February 2020. Most of the respondents think that they are including integrated teaching into their lessons. Over half of that respondents include it using project or modules or topics that are part of more than one subject. The main reasons for not implementing integrated teaching are that it takes too much time and that they do not know how to implement it into their lessons. In our research we collected data about integrated teaching in secondary schools in the Czech Republic. One of the reasons for not including integrated teaching into respondents' lessons is that they do not know how. Because of that we are preparing an integrated module that they can employ.

Keywords: Integrated teaching, secondary schools, teacher's opinion

Introduction

One of the ideas about concepts of education for the future is using principles of integration in education. The added value of integration is enrichment of final complex with a new quality that separated parts could not bring – integration therefore uses synergistic effect. The use of integrated teaching overcomes the fragmentation of knowledge in individual subjects, instead it represents a topic in context. And that is an important aspect for using knowledge in real life (Bartoňová & Kričfaluši in press).

"Knowledge should not be divided into different subjects or compartments but should be discovered as an integrated whole…The discussions about integrated education focused on the integration of teaching content are frequently held. The future will show whether it is a fashion or necessity" (Lamanauskas, 2010).

We wanted to find out the opinion od secondary school teachers in the Czech Republic on integrated teaching, its value and methods of its implementation. With this aim in mind we realized two questionnaire survey – first pilot survey in December 2018 only on the territory of the Moravian-Silesian Region (Bartoňová & Kričfaluši in press). Second survey was realized at the turn of 2019/2020 throughout the Czech Republic. The results of the second research are presented in this paper.

Integrated teaching is perceived in many ways. In our research we decided to use these two definitions to express our point of view: *Integrated teaching is teaching in which the educational contents of subjects are interconnected while the integrated educational content follows the goals of all integrated subjects* (Rakoušová, 2011). *It implements interdisciplinary relationships and connects theoretical and practical activities* (Průcha, Walterová & Mareš, 2013).

Integrated teaching is related to two more concepts – inter-subjects' relations and interdisciplinary approach. In Czech literature we can found that *inter-subjects' relations are links between specific subjects that go beyond understanding the context of sub-contents, it's the means of integration of the content of education*

(Průcha, Walterová & Mareš, 2013). *Interdisciplinary approach is didactic approach supporting inter-subjects' relations in teaching, assignment of special task that connects knowledge from various subjects, team teaching, creation of so-called integrated subjects, creation of integrated textbooks* (Průcha et al., 2013).

To understand these three concepts more deeply, we may use 10 models that teachers can use to design integrated curriculums from publication *Ten ways to Integrate Curriculum* written by Robin Fogarty. These ten models can be then divided into three groups – integration within single disciplines, across several disciplines, within and across learners. If we look into the group of integration across several disciplines, we may see inter-subjects' relations as The Shared Model, interdisciplinary approach as The Webbed Model and integrated teaching as The Integrated Model. *"The **shared model** views the curriculum through binoculars, bringing two disciplines together into a single focused image. Using overlapping concepts as organizing elements, this model involves shared planning or teaching in two disciplines"* (Fogarty, 1991 p. 62). "*The **webbed model** of integration views the curriculum through a telescope, capturing an entire constellation of disciplines at once. Once a cross-departmental team has chosen a theme, the members use it as an overlay to the different subjects. Inventions, for example, lead to the study of simple machines in science, to reading and writing about inventors in language arts, to designing and building models in industrial arts, to drawing and studying Rube Goldberg contraptions in math..."* (Fogarty, 1991 p. 63). In **The Integrated Model** "*interdisciplinary topics are rearranged around overlapping concepts and emergent patterns and designs...The integration sprouts from within the various disciplines, and teachers make matches among them as commonalities emerge"* (Fogarty, 1991 p. 64).

In our Framework Educational Programme for Secondary General Education (Grammar schools) is the idea of integrated teaching supported by following words: *"The aim of education at a grammar school is not to present the pupils with the greatest amount of component knowledge, facts and data possible but to provide them with a systematic and well-balanced structure of knowledge,* *teach them to incorporate information into a meaningful context of everyday practice and instil in them the desire to develop their knowledge and skills further throughout their lives. A prerequisite of this is that approaches and methods stimulating the pupils' creative thinking, resourcefulness and independence be employed, differentiated instruction and new organisational forms utilised, integrated subjects incorporated, etc. in the education."* (Framework Educational Programme for Secondary General Education, 2007 p. 8).

There are some researches about advantages of integrated teaching. For example, in the end of 20th century John A. Ross and Anne Hogaboam-Gray did a research on the effects on students by integrating mathematics, science and technology. They compared a school that integrated mathematics, science and technology in grade 9 to a school in the same district that taught them separately. The results show that *"curriculum integrating math, science, technology increased students' ability ty apply learning outcomes that were important in all three subjects without reducing achievement in the learning outcomes unique to each subject"* (Ross & Hogaboam-Gray, 1997 p. 19). "*In addition, female students performed better on science outcomes in an integrated setting than they did when each subject discipline was taught separately"* (Ross, Hogaboam-Gray, 1997 p. 21). The results shown that the curriculum integration contributed to students' motivation and students' ability to work together. The curriculum integration had "*a mixed effect on students' attitudes toward evaluation*" (Ross & Hogaboam-Gray, 1997).

Methods

The source of our data was an online questionnaire made with Google Forms. An e-mail with a request to join the survey was send to all secondary schools in the Czech Republic. The list of schools was taken from the database of the Ministry of Education, Youth and Sports, that is available from its website. The data was collected from December 2019 to February 2020.

The first part of the questionnaire included 4 basic questions about the type of school and region that the respondent is teaching, the length of respondents' teaching practice, subjects that the respondent is teaching. Followed by 4 questions about integrated teaching. It was found out how the respondents like the idea of integrated teaching, if the respondents think that integrated teaching is beneficial for students, whether it is the duty of Czech teachers to include integrated teaching in their lessons and if they do or do not include integrated teaching in their lessons.

The second part was different for the respondents that choose that they do include integrated teaching in their lessons and for those that do not. If the respondents do include integrated teaching into their lessons, we asked in which form and how often do they include integrated teaching into their lessons, what kind of materials do they use to prepare integrated teaching. If the respondents do not include integrated teaching into their lessons, we asked about the main reasons why so.

Results

A total of 993 respondents participated in our research (341 grammar-school teachers and 652 teachers of other kinds of secondary schools). Respondents are teachers with various length of teaching practice (see Figure 1). A total of 20 % of respondents have more than 30 years of experience in teaching. Respondents were from all regions of the Czech Republic. The comparison between the percentage of secondary school teachers and the percentage of respondents in individual regions is shown in Figure 2 . Respondents are teachers of all kinds of subjects. Almost 30 % of respondents are teachers of vocational subjects, 24 % of respondents are teachers of the Czech language, 19 % of respondents are Math teachers (see Figure 3).

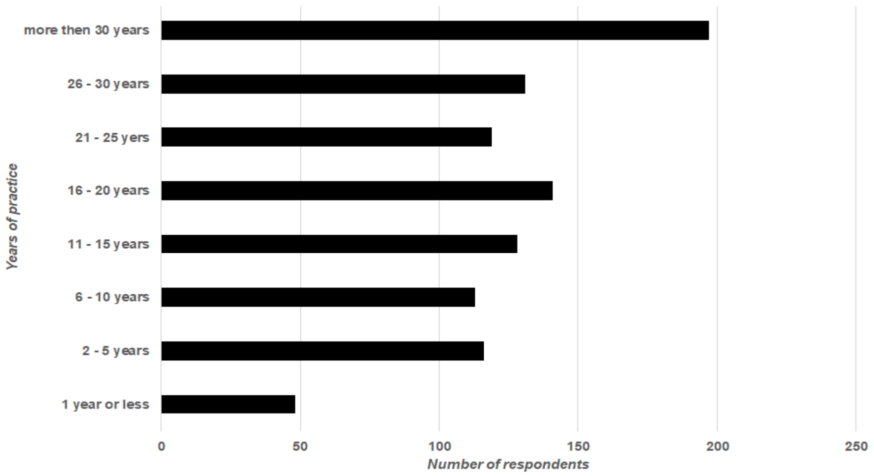

Fig. 1. Respondents according their length of teaching practice (Authors)

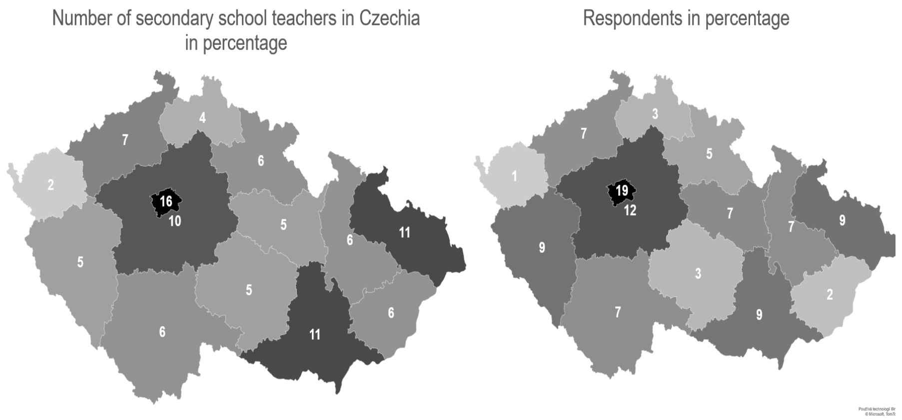

Fig. 2. Comparison between number of secondary school teachers in Czechia and respondents in specific regions of the Czech Republic (left: data from Maršíková, M. & Jelen, V. (2019). Hlavní výstupy z Mimořádného šetření ke stavu zajištění výuky učiteli v MŠ, ZŠ, SŠ a VOŠ [online]. MŠMT. Available from: http://www.msmt.cz/file/50371/, right: Authors)

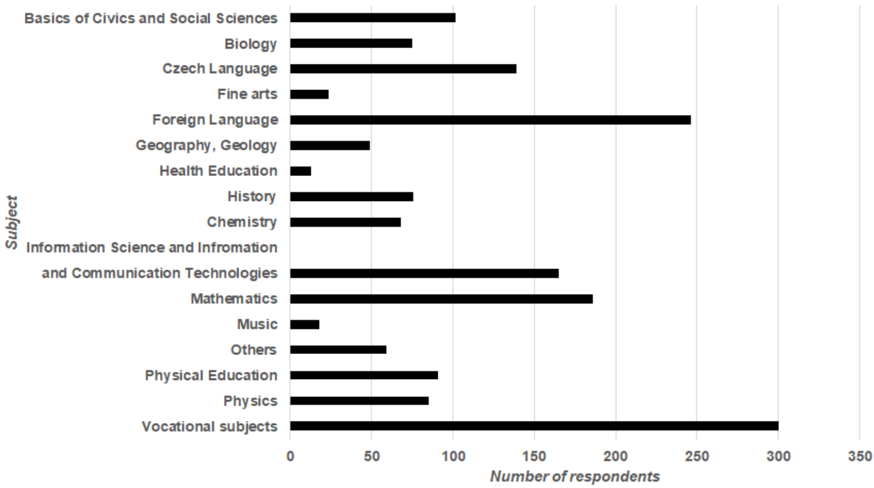

Fig. 3. Respondents according to subjects they are teaching (Authors)

To review the reliability of the results of the questionnaire survey, the level of agreement between the answers in two randomly created groups of respondents was determined. From all 993 respondents was chosen 100 respondents for group 1 and 100 respondents for group 2 using random number generator. The level of agreement was expressed by Cohen's kappa coefficient (hereinafter referred as "κ"). In our research we got the values of Cohen's kappa coefficient in three ranges. The following link between Cohen's kappa coefficient, level of agreement and percentage of data reliable are taken from McHugh, 2012. Our first range of Cohen's kappa values is between 0.60-0.79 which corresponds to moderate level of agreement (35-63 % of data are reliable). The second range is between 0.80-0.90 which corresponds to strong level of agreement (64-81 % of data are reliable). One of the results has κ equal to 0.9519. That means almost perfect level of agreement (82-100 % of data are reliable). A Likert scale was used in the questionnaire with question *"The integrated teaching is beneficial for students"*. Respondents had to choose from strongly agree, rather agree, rather disagree, strongly disagree and I don't know. Most of the respondents rather agree or strongly agree with this statement. Only 2 % strongly disagree with this statement and 6 % of respondents rather disagree with it (see Figure 4). Cohen's kappa coefficient for this question is equal 0,9519.

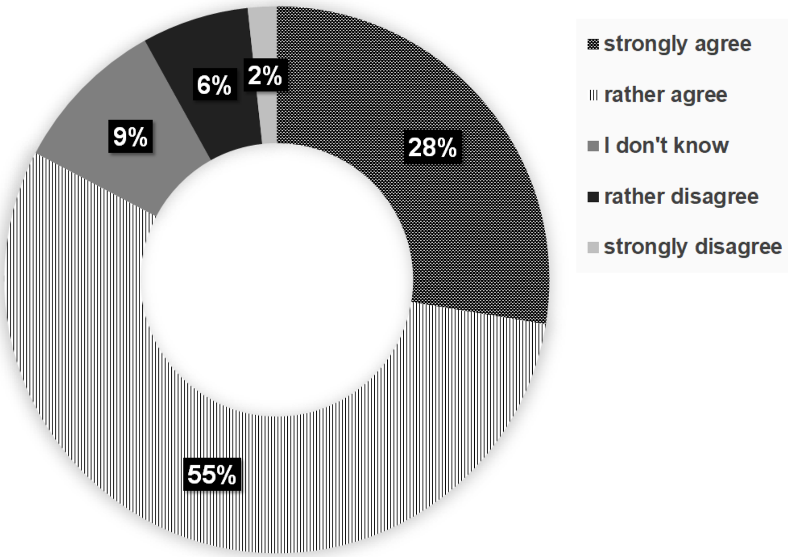

Fig. 4. Respondents answers for statement "The integrated teaching is beneficial for students" (Authors)

The respondents were asked whether "*it is the duty of Czech teachers to include integrated teaching in their lessons*". 70 % of respondents answered "no" (κ = 0.7288).

A total of 68 % of respondents answered that they do include integrated teaching into their lessons (κ=0.709). We wondered if there is any difference between responses of grammar-school teachers and other teachers. Only 3 % more of teachers from other kinds of schools than grammar-school answered that they do include integrated teaching into their lessons (see Figure 5). We also wanted to find out whether the incorporation of integrated teaching into classes also differs within individual regions. We calculated the percentage of participants from each region that do include integrated teaching into their lessons from the total number of participants in that region. We came to the following results: A total of 81 % of respondents from Vysočina region do include integrated teaching into their lessons followed by 75 % of respondents of Central Bohemian Region and 73 % of respondents from the main city Prague (see Figure 6).

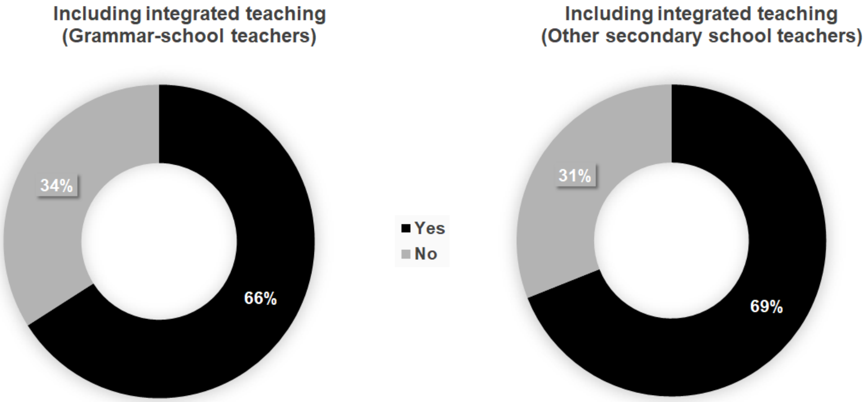

Fig. 5. Comparison of answers to question "Do you include integrated teaching into your lessons" between grammar-school teachers and other secondary school teachers (Authors)

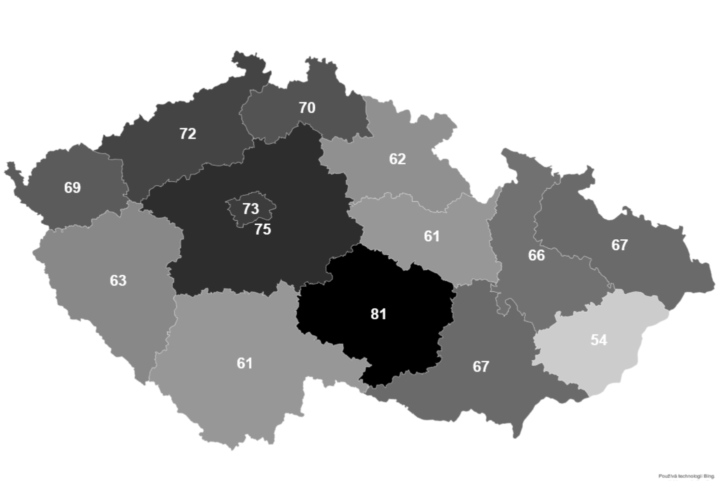

Fig. 6. Comparison of teachers that are including integrated teaching into their lessons in specific regions of Czechia in percentage (Authors)

We may get an idea of how integrated teaching is incorporated into the lessons based on secondary school teachers' answers to questionPředstavu o způsobu realizace IV si lze vytvořit na základě odpovědí učitelů na otázku "*In which form do you include integrated teaching in your lessons?*. The most common answer was **the inclusion of projects** that are connecting knowledge from more subjects with practical experience and productive activities. A total of 412 respondents have chosen this answer. The second most common answer was that the respondents work with **modules or topics, that are included as a part of more subjects**. A total of 345 respondents have chosen this answer. A total of 129 respondents have chosen that they prepare **integrated days** when the whole school realize one common topic and 41 respondents had respond that integrated teaching is included in **special integrated subjects** like Science (See Figure 7). Some respondents choose the other option and write down their own form of realizing integrated teaching e.g. *expedition, monothematic days, CLIL method, making a movie*.

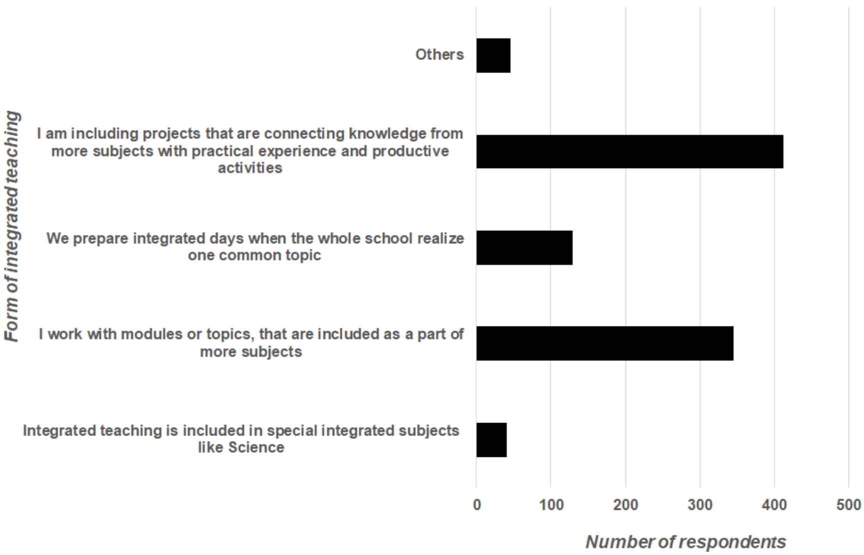

Fig. 7. Respondents answers to question "In which form do you include integrated teaching in your lessons?" (Authors)

Most of the respondents that have respond that they do include integrated teaching into their lessons include it more than once a month. A total of 186 respondents respond that. A total of 177 respondents include integrated teaching into their lessons once a month, 159 respondents include it less than once a month and 123 respondents include it once or twice a year. Other respondents were not able to say how often they include integrated teaching into their lessons (see Figure 8).

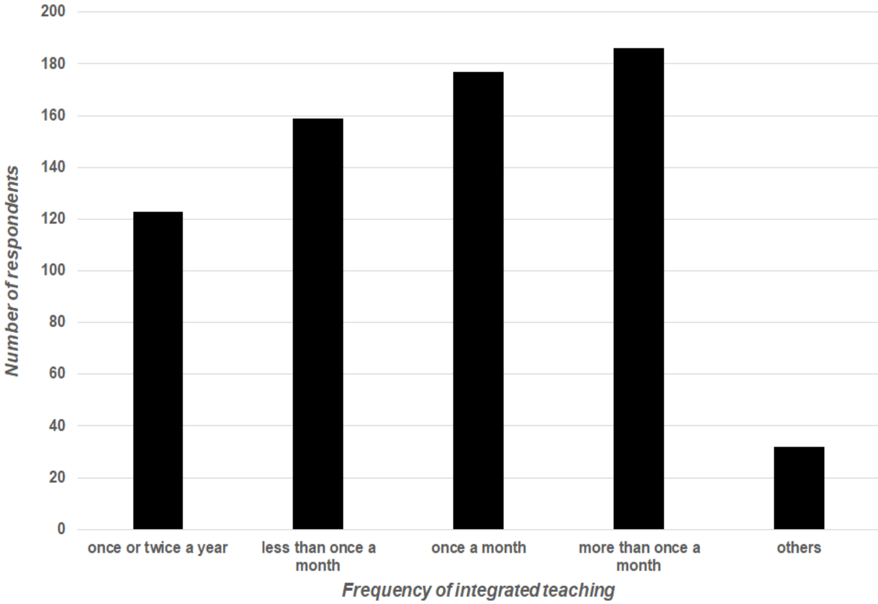

Fig. 8. Respondents answers to question "How often did you include integrated teaching into your lesson last school year (2018/2019)?" (Authors)

Discussion

For our research we decided to choose wide sample of secondary school teachers of all subjects, regions and with different length of their teaching practice. We wanted to get an idea of current situation in the Czech Republic about integrated teaching in secondary schools. In December 2018 we made a pilot questionnaire that we send to all secondary schools in Moravian-Silesian region (hereinafter as "MSR") only. Finding on this research are similar to those from the research in December 2018.

A total of 68 % of respondents answered that they do include integrated teaching into their lessons. In our research in MSR from December 2018 a total of 66 % of respondents answered that they do include integrated teaching into their lessons. To understand it more clearly, we add in this research a question about *how often they include integrated teaching.* We also asked in *which form do they include integrated teaching into their lessons.* Most of the respondents do include integrated teachingrat least once a month. Considering that - from our experience - teachers complain a lot that they do not have enough time to teach their students all content from the syllabus, there is not enough room for them to fully include integrated teaching so often. Moreover, the most common form of integrated teaching was projects and the second most common answer was that they work with modules or topics, that are included as a part of more subjects. As the projects takes a lot of time, I do not presume that they are really incorporated more than once a month. What could be incorporated is working with topics and modules that are part of more subjects. But do teachers really incorporatd integrated teaching or do they just mention links between subjects. When respondents write down their own answer to the question about in which form do they include integrated teaching, they answered that they do include inter-subjects' relations. So, we may presume that in fact there is a smaller number of teachers, that actually do include integrated teaching into their lessons. We can also presume that teachers think that they are including integrated teaching but in fact they are just including inter-subjects' relations.

Most of the respondents rather agree or strongly agree with the statement: *"The integrated teaching is beneficial for students"*. That corelates with the results of the research that was made in 2007 by J. Škoda & P. Doulík. In their research respondents most often chosee the option *"rather agree"* for the statement *"I consider the integration teaching of science subject to be appropriate"* (Škoda & Doulík, 2007). It also corelates with results from our pilot survey in MSR. In our pilot survey 88 % of respondents think that integrated teaching is beneficial for students (Bartoňová & Kričfaluši Bartoňová & Kričfaluši in press).

As we mentioned before we wondered if there will be any difference between teachers in grammar-schools and teachers in other secondary schools in answers to question whether they do or do not include integrated teaching into their lessons. But as our result shown only 3 % more of the teachers from other kinds of schools answered that they are including integrated teaching into their lessons. So, there is no significant difference between answers from grammar-school teachers and others. When we compared the percentage of "*yes*" answers to question if teachers *do include integrated teaching into their lessons* between regions in the Czech Republic, we found some differences. A total of 81 % of respondents from Vysočina region do include integrated teaching into their lessons and on the other hand only 54 % of respondents from Zlín region do include it into their lessons. But we have to consider that we did not have enough number of respondents from each region so we may consider this data as an idea that could be more investigated.

Conclusions and implications

Our research about current situation in the Czech Republic about integrated teaching come up with findings that can be explored more deeply. From our results we may say that secondary school teachers in the Czech Republic agree with the statement that integrated teaching is beneficial for students but not all of them actually include integrated teaching into their lessons. And if they do (in their opinion), we may not be certain if it is so or if they just think they are including integrated teaching into their lessons but in fact they do not. Results of our research also broad up some questions that we may be asking. *Do teachers know what integrated teaching is? Do they differ integrated teaching from inter-subjects' relations? Is there a big difference with including integrated teaching between secondary school teachers in specific regions in the Czech Republic?* And if so, *what could be the reasons of this difference?* These questions need to be further investigated to get a clearer idea about current situation in secondary schools in the Czech Republic about integrated teaching.

References

Bartoňová, M. & Kričfaluši, D. (2020). Názory a povědomí učitelů Moravskoslezského kraje o integrované výuce a její realizaci na středních školách. Biologie-chemie-zeměpis. [article in press].

Fogarty, R. (1991). Ten Ways to Integrate Curriculum. Educational Leadership, 49(2), 61-65.

Framework Education Programme for Secondary General Education (Grammar schools). (2007). Praha: Výzkumný ústav pedagogický v Praze. Dostupné z: http://www.nuv.cz/file/161

Lamanauskas, V. (2010). Integrated science education in the context of the constructivism theory: some important issues. Problems of education in the 21st century, 25, p. 5-9.

McHugh, M. L. (2012). Interrater reliability: the kappa statistic. Biochemia medica, 22(3), p. 276–282. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3900052/

Průcha, J., Walterová, E., & Mareš, J. (2013). Pedagogický slovník. Nové, rozšířené a aktualizované vydání. Praha: Portál.

Rakoušová, A. (2011). Integrace obsahu vyučování v primární škole. Integrované slovní úlohy napříč předměty. Praha: Grada.

Ross, J. A. & Hogaboam-Gray, A. (1998). Integrating mathematics, science, and technology: Effects on students. International Journal of Science Education, 20(9), 1119-1135.

Škoda, J. & Doulík, P. (2007). Jaké možnosti přinášejí RVP ZV pro přírodovědné vzdělávání? In Člověk a příroda: první krok k integraci výuky přírodovědných předmětů. Sborník příspěvků z mezinárodní elektronické konference (p. 7-31). Ústí nad Labem: Univerzita J. E. Purkyně v Ústí nad Labem, Pedagogická fakulta.

STUDENT AT SCHOOL IN PISA RESEARCH - A CONSCIOUS CITIZEN?

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Abstract

The rapidly growing role of digital technologies, information bubbles, media manipulation, information smog, FOMO, phonoholism, or major changes in the labour market - this is the reality live for young people at school age. How to find values in such an environment and keep common sense thinking? The EU Council Recommendation of 22 May 2018 on Key Competences for Lifelong Learning enshrined the following: "Order to maintain current living standards, promote a high level of employment and strengthen social cohesion in the context of future society and the world of work, people need the right mix of skills and competences" (Council of the European Union Recommendation). Are science subjects good environments to shape such competences? How to teach in order to shape a conscious citizen? How to ensure sustainable development? An attempt was made to answer these questions on the basis of selected cognitive science items as well as contextual questions from the Programme for International Student Assessment (PISA) study. PISA framework defines scientific literacy under four aspects, namely contexts, knowledge, competencies, and attitudes. In this study, the students' answers were analyzed from different point of view, for example: the ability to distinguish between what is an opinion and what is a fact; the importance of being able to apply scientific knowledge in the context of real-life situations or draw evidence-based conclusions about science-related issues (OECD, 2019).

Key words: PISA, science, citizen, science items

The rapidly growing role of digital technologies, information bubbles, media manipulation, information smog, FOMO, phonoholism, or major changes in the labour market – this is the reality for young people at school age. How to find values in such an environment and keep common sense thinking? The EU Council Recommendation Key Competences for Lifelong Learning enshrined the following: “Order to maintain current living standards, promote a high level of employment and strengthen social cohesion in the context of future society and the world of work, people need the right mix of skills and competences” (2018).

Are science subjects lessons a good environments to master such competences? How to teach in order to bring up a conscious citizen? How to ensure sustainable development? An attempt was made to answer these questions on the basis of selected cognitive science items as well as contextual questions from the Programme for International Student Assessment (PISA) study. PISA framework defines scientific literacy under four aspects, namely contexts, knowledge, competencies, and attitudes. In this study, chosen PISA cognitive items were analyzed from different point of view in accordance to students’ skills assessment (OECD, 2018).

The OECD Education at a Glance 2012 – HIGHLIGHTS (2012) report shows that between the ages of seven and fourteen, Poles spend over six thousand hours at school (Figure 1). What is the result of this time spended at school? How is it consumed?

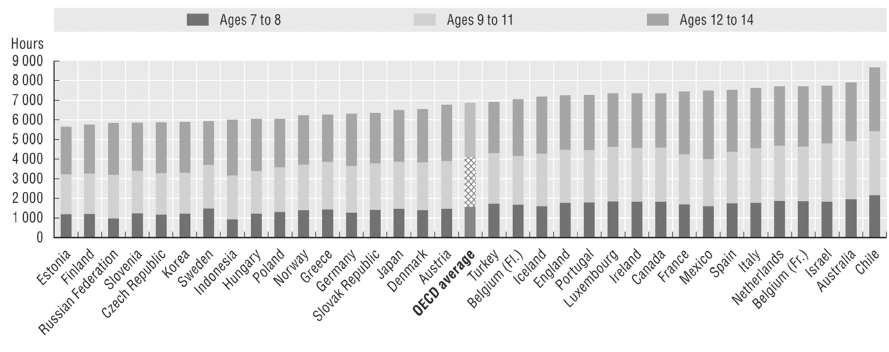


Fig. 1. Number of hours children spend at school between the ages of seven and fourteen. Source: OECD Education at a Glance 2012 – HIGHLIGHTS (2012)

The preamble to the core curriculum of general primary education in Poland states: "... the most important goal of primary school education is to care for the integral biological, cognitive, emotional, social and moral development of the (…) student. Education (...) creates a coherent whole and constitutes the foundation of education enabling diverse professional qualifications, followed by their improvement or modification, opening the lifelong learning process". (MEN, 2017; MEN, 2018). On the other hand, the preamble to the core curriculum for high school and technical secondary school states: "In the general education process, the school shapes attitudes among students that favor their further individual and social development, such as: honesty, credibility, responsibility, perseverance, self-esteem, respect for other people, cognitive curiosity, creativity, entrepreneurship, personal culture, readiness to participate in culture, take initiatives and to teamwork. In social development, it is very important to shape civic attitude, attitude to respect the tradition and culture of one's own nation, as well as an attitude of respect for other cultures and traditions. The school cares for the education of young people in a spirit of acceptance and respect for others, shapes the attitude of respect for the natural environment, motivates to take action for environmental protection and develops interest in ecology".

Thinking broadly and beyond the given science subject matter of the teaching-learning process, it is worth recalling the provisions of the Council of the European Union Recommendation of 22 May 2018 on key competences (2018/C 189/01):

"Everyone has the right to quality and inclusive education, training and lifelong learning in order to maintain and acquire skills that allow full participation in society and successful transitions in the labour market.

People need the right set of skills and competences to sustain current standards of living, support high rates of employment and foster social cohesion in the light of tomorrow's society and world of work".

What is more – in the same document one may read that "…international surveys such as the Organization for Economic

Cooperation and Development (OECD) Programme for International Student Assessment (PISA) or the OECD Programme for the International Assessment of Adult Competencies (PIAAC) indicate a constant high share of teenagers and adults with insufficient basic skills". Why is this so important right now? There are signs in various sources that the world as we know it is ending. On the one hand, it is obvious that climate change is happening right before our eyes – COVID-19 pandemic, water pollution, increased greenhouse effect and drought, which have already led to waves of emigration and international conflicts. In 2018, scientists from the Australian Think Tank – Breakthrough National Center for Climate Restoration submitted an official application to the Foreign Affairs, Defense and Trade Committee of the Australian Senate regarding the study of long-term threats related to change climate for national security and international security (Spratt, et al., 2017). The end of the world we know is also manifested in the technological and cultural revolution: globalization, widespread economic migration, development of mass communication techniques, international change in the demographic composition of the workforce, as well as atomization of societies. Camus wrote that the school is preparing for life in a world that does not yet exist. What changes in the abovementioned range are occurring specifically? Some examples can be cited:

- In the years 2000 – 2010, 1.1 million secretaries disappeared from the US labor market, by 63 percent the number of typists decreased by 46% travel agents (THINKTANK Center for Dialogue and Analysis, 2013);
- Almost half (47%) of the currently known professions will be replaced by machinery in the next 25 years (Gumtree, 2017);
- Robots will replace 800 million jobs by 2030 (Ma, 2018);
- 65% of current primary school students will work in professions that do not yet exist (Ma, 2018).

So what is the role of a modern school? Who is and who is to be a conscious citizen? What values, skills and competences are important in a dynamically changing reality? Some of these questions can be answered in the largest international student skills survey – PISA (Sitek & Ostrowska, 2020). The study shows the level and diversity of skills of fifteen-year-olds that are developed during school education and outside of school: reading, mathematical, science, and financial literacy. It is worth remembering that the school should work by educating key skills that are necessary for future self-fulfillment, personal development, adopting active citizenship, achieving social integration and employing a student on the labor market.

A conscious citizen should (among others):

- be able to distinguish what is an opinion and what is a fact – e.g. when watching advertisements;
- relate knowledge from school to everyday life;
- search for honest information;
- on the basis of the leaflet attached to the drug, assess precautions to its intake;
- be able to consciously decide in a vote about building a nuclear power plant;
- in discussion, taking into account substantive arguments, not emotions;
- distinguish between scientific and unscientific arguments.

What student-citizen can we raise in science classes? Figure 2. presents student features that are worth deliberately shaped in class.

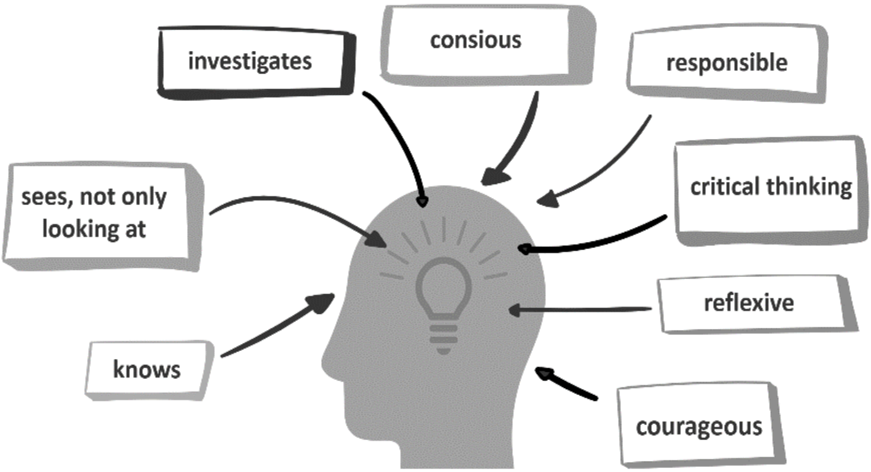
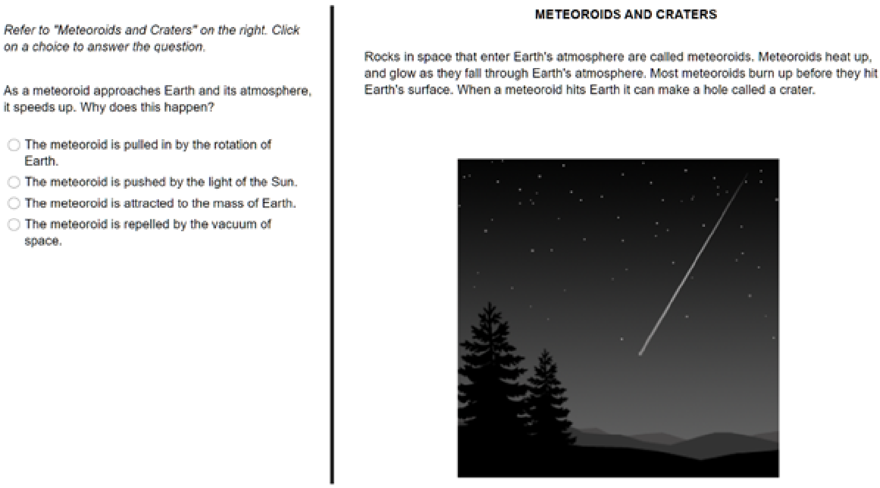


Fig. 2. Characteristics of a student – an conscious citizen, which are worth forming in the course of science subjects (and not only science subjects)1.

[1]Some those features, e.g. courage are examined in the PISA questionnaire only – not in the cognitive tasks. To provide a full picture, however, we decided to discuss also those traits of a student – citizen, which are not covered by the items used in the PISA.

The shaping of the conceptual apparatus is the basis for further conscious participation of the student in society – the conceptual apparatus should be developed enough for young people to be able to communicate on important matters. You need a completely basic, but (what is extremely important) error-free knowledge, the ability to analyze sources and to communicate and express your own opinion. It is also worth paying attention to language correctness in students' statements and checking whether they have incorrect beliefs, in particular incorrect language beliefs (Markowska et al., 2014; Chrzanowski, et al., 2018). Below is an example of a task from the PISA 2015 release item to check students' knowledge (OECD, 2015).


Refer to "Meteoroids and Craters" on the right. Click on a choice to answer the question.

As a meteoroid approaches Earth and its atmosphere, it speeds up. Why does this happen?

- ◯ The meteoroid is pulled in by the rotation of Earth.
- ◯ The meteoroid is pushed by the light of the Sun.
- ◯ The meteoroid is attracted to the mass of Earth.
- ◯ The meteoroid is repelled by the vacuum of space.

METEOROIDS AND CRATERS

Rocks in space that enter Earth's atmosphere are called meteoroids. Meteoroids heat up, and glow as they fall through Earth's atmosphere. Most meteoroids burn up before they hit Earth's surface. When a meteoroid hits Earth it can make a hole called a crater.

Question requires students to apply simple scientific knowledge to select the correct explanation for why objects speed up at they approach Earth.

STUDENT SEES - A GOOD CITIZEN IS TO BE A GOOD OBSERVER WHICH NOT ONLY LOOK AT SOMETHING BUT REALLY SEE IT CONSCIOUSLY

The skill of careful observation is essential for critical analysis of reality and reflection. To devote yourself to observation, you need to stop for a while, and this is not easy in a dynamically changing world.

Especially for students – representatives of the *instant generation*. Simple exercises can be a test of observation skills (Siporska & Chrzanowski, 2020):

A tomato

"Think what the tomato looks like and make two drawings of a tomato: transverse cross-section and longitudinal cross-section.

A TOMATO	
transverse	longitudinal

Write down your reflections. Was it an easy or rather hard task for you? Why?"

Cubes

"The foods we eat come in all shapes and sizes, but something beautiful happens if you cut it all down to size — literally. Design studio Lernert & Sander did just that to make the remarkable piece of art below (Figure 3), which was commissioned by Dutch newspaper De Volkskrant last year for a feature on the nation's eating habits. The very act of cutting each food from corn and salmon to cauliflower and kiwi into 2.5-centimeter cubes shows just how unique the nature can be. By attempting to force the nature to conform, the differences between each fruit, vegetable, and slab of meat becomes even more apparent (and beautiful)[2].

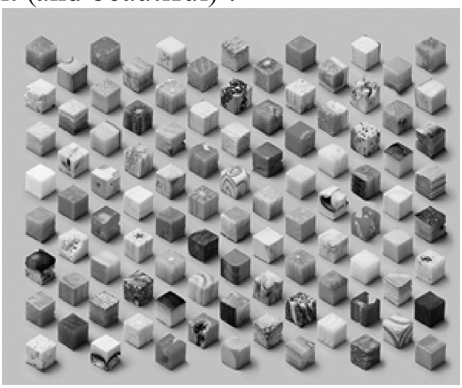


Fig. 3. A design made by Lernert & Sander studio.

[2]Cubes of fruits, vegetables, and meats will make you see food in a new light, Dante D'Orazio, The VERGE, May 16, 2015

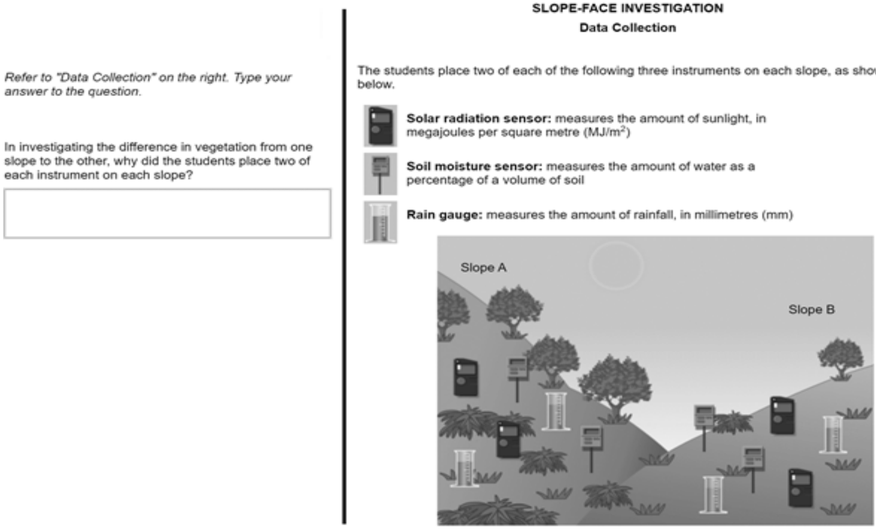
1. Write down how many cubes are there in the figure. Do not count them, just try to estimate.
2. Now count them and write the exact number.
3. Do you think that observation skills are something important to science? If yes – where might they be used?
4. Now look one more time at the figure with cubes. For each of 8 chosen rows, try to write at least three names of substances the cubes are made of.
5. What do you think about your observation skills?"

STUDENT INVESTIGATOR

Another feature presented in Figure 2. is the student as a researcher. "Children are born researchers, exploring the natural world is naturally associated with studying the world around the child" (Poziomek et al., 2016). Using the science method and teaching it in class may cause the development of the certain students' thinking habits: scientific critical thinking, whose features are: objectivity, source, accuracy and versatility, asking verifiable questions, sensitizing to data manipulation. Thanks to the work of the inquiry-based method (IBSE), the student learns how science is being constructed, where it comes from, and what distinguishes it from pseudoscience. Thanks to this the student understands: what scientists say, why scientists say what they say, why scientists say so and not otherwise as well, and why scientists rarely answer 'yes' or 'no' questions.

The basic concepts of the scientific method, such as a research problem or hypothesis can be easily introduced and practiced using an artifact - Fortune Teller Fish. More on this topic can be found in paper entitled: *Interdisciplinarity in science teaching* (Chrzanowski, 2018). In the PISA, great emphasis is placed on the evaluation of skills in the field of scientific method. An example of such tasks is *Slope-Face Investigation* (OECD, 2015). Question requires students to apply epistemic knowledge to explain the design of the investigation presented in this unit. To earn the full credit the student gives an explanation that identifies a scientific advantage of using more than one measurement instrument on each slope, e.g. correcting for variation of conditions within a slope, increasing the precision of measurement for each slope, for example:

- So they could determine whether a difference between slopes is significant,
- Because there is likely to be variation within a slope,
- To increase the precision of the measurement for each slope.



CONSIOUS AND RESPONSIBLE STUDENT

The student – citizen – should also be aware and responsible for himself and others – should orientate him- or herself in the surrounding reality, observe public debate and look for information on current, important topics such as: biotechnology, *in-vitro*, sustainable development or vaccination. Sensitizing to the beauty and value of nature, will certainly have a positive impact on the student's attitude to the natural environment. It is also worth modeling the behavior of students with our own behavior – in this way we can show students how our behavior on a micro scale entails global changes – conscious consumer choices made by the teacher, conversations with students regarding natural resources saving, recycling and upcycling will sensitize young people to what happens in their home and in the immediate vicinity. The school should also strengthen the ethical behavior of students – developing internal students' motivation should reduce the frequency of unethical behavior. PISA tests the knowledge and attitudes of students regarding social topics important for their safety and their loved ones. One of such tasks is the item about vaccination - Mary Montagu (OECD, 2009).

> MARY MONTAGU
>
> Give one reason why it is recommended that young children and old people, in particular, should be vaccinated against influenza (flu).

CRITICAL THINKING STUDENT

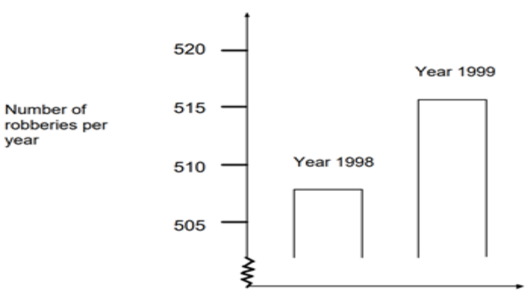
Science classes are the perfect time to practice critical thinking skills with students. A critical thinking student

- is aware of manipulations, and is able to distinguish facts from opinions,
- analyzes media coverage, including information from advertising or various types of campaigns,
- when making decisions takes into account facts, not (or not only) emotions or intuition,
- is looking for reliable sources of information.

These extremely important skills may be developed and mastered by asking students to search for information and provide their sources, analyze and evaluate the reliability of source data, e.g. information from advertisements, statements by politicians, celebrities or popular science threads in TV series and films (OECD, 2009). It is worth pointing to an example task from the mathematical part of the PISA study released in 2006, which students are asked to analyze and interprete of a misleading graphs and decide if the journalist accurately described the information presented in the chart:

A TV reporter showed this graph and said:

"The graph shows that there is a huge increase in the number of robberies from 1998 to 1999."



Do you consider the reporter's statement to be a reasonable interpretation of the graph? Give an explanation to support your answer.

REFLEXIVE STUDENT

Science classes are also a very good opportunity to educate the student as a reflective person on the one hand and brave on the other. A reflective student observes reality, asks questions about it, puts hypotheses, looks for differences and similarities. A reflextive student understands that the existence of not only similarities but also differences in larger groups is not uncommon. A useful tool in shaping such an attitude is statistics, even the basic one, which is used at school in maths and science classes. You can practice with students describing some data set – it will certainly reveal the distribution of the values of a given characteristic – height / weight, color of the eyes or hair of the students in the class, length of leaves on a given tree, etc. It is also worth practicing with students asking questions that can be answered using information from the text. Asking questions can sometimes be uncomfortable – a brave student is not afraid to ask questions, but is not afraid to look for answers, participates in the discussion, defends his or her opinion giving factual arguments and not getting carried away .

In PISA, students are often asked to analyze a situation / problem from different points of view. The following is a task of this type belonging to the financial part (OECD, 2012).

NEW OFFER

Mrs Jones has a loan of 8000 zeds with FirstZed Finance. The annual interest rate on the loan is 15%. Her repayments each month are 150 zeds.

After one year Mrs Jones still owes 7400 zeds.

Another finance company called Zedbest will give Mrs Jones a loan of 10 000 zeds with an annual interest rate of 13%. Her repayments each month would also be 150 zeds.

If she takes the Zedbest loan, Mrs Jones will immediately pay off her existing loan.

What are **two** other benefits for Mrs Jones if she takes the Zedbest loan?

1. ....

2. ....

What is one possible **negative** financial consequence for Mrs Jones if she agrees to the Zedbest loan?

....

The item requires students to consider the financial benefits of taking a particular loan. Personal loans fall into the individual context since there are benefits, disadvantages and legal consequences for the person taking out the loan. The item also tests students' understanding of the relevant financial concepts such as repayment and penalty fees in relation to a loan and their implications.

The eight features listed in Figure 2 and described in the paper certainly do not exhaust all of the features, but give us room for further discussion and valuable use of at least part of the six thousand hours that students spend in class at school. Teaching science subjects can be one way to create the essential general skills needed today. Science tasks testing these skills can be a good diagnostic tool.

References

Chrzanowski, M.M., Grajkowski, W., Żuchowski, S., Spalik, K. & Ostrowska, E.B. (2018). Vernacular Misconceptions in Teaching Science – Types and Causes. *Journal of Turkish Science Education, 15(4), 29-54.*doi:10.12973/tused.10244a

Chrzanowski, M.M. (2018). Interdyscyplinarność w nauczaniu przedmiotów ścisłych. Refleksje. *Zachodniopomorski Dwumiesięcznik Oświatowy,* 3/2018

Council Recommendation of 22 May 2018 on key competences for lifelong learning (Text with EEA relevance), (2018/C 189/01).

Gumtree (2017). *AKTYWNI+ PRZYSZŁOŚĆ RYNKU PRACY, Report*.

Ma, J. (2018). *Presentation during the World Economic Forum in Davos.*

Markowska, A., Lechowicz, M., Grajkowski, W., Chrzanowski, M., Ostrowska, E.B. & Spalik, K. (2014). *Błędne przekonania w nauczaniu przedmiotów przyrodniczych, Edukacja Biologiczna i Środowiskowa, 53(4), 56-66.*

MEN. (2017). *Rozporządzenie Ministra Edukacji Narodowej z dnia 14 lutego 2017 r. w sprawie podstawy programowej wychowania przedszkolnego oraz podstawy programowej kształcenia ogólnego dla szkoły podstawowej, w tym dla uczniów z niepełnosprawnością intelektualną w stopniu umiarkowanym lub znacznym, kształcenia* *ogólnego dla branżowej szkoły I stopnia, kształcenia ogólnego dla szkoły specjalnej przysposabiającej do pracy oraz kształcenia ogólnego dla szkoły policealnej, Dz.U. 2017 poz. 356*

MEN. (2018). *Rozporządzenie Ministra Edukacji Narodowej z dnia 30 stycznia 2018 r. w sprawie podstawy programowej kształcenia ogólnego dla liceum ogólnokształcącego, technikum oraz branżowej szkoły II stopnia*, *Dz.U. 2018 poz. 467*

OECD. (2009). *Take a test*. OECD Publishing. https://www.oecd.org/pisa/pisaproducts/Take%20the%20test%20e%20book.pdf

OECD. (2012). *Education at a Glance 2012: Highlights,* OECD Publishing. http://dx.doi.org/10.1787/eag_highlights-2012-en

OECD. (2016). PISA 2015 Results (Volume I): Excellence and Equity in Education, PISA, OECD Publishing, Paris. http://dx.doi.org/10.1787/9789264266490-en

OECD. (2019). *PISA 2018 Assessment and Analytical Framework*, Paris: PISA, OECD Publishing. https://doi.org/10.1787/b25efab8-en.

Polish Analytical Centre THINKTANK. (2013). *RE-WIZJE. Jak w najbliższej dekadzie zmieni się państwo, rynek, praca, edukacja, styl życia i miejsce Polski w Europie"*

Poziomek, U., Marszał, D., Skrobek, A.M., Woźniak M. & Żurawska, I. (2016). Przyrodnicza edukacja przedszkolna i wczesnoszkolna. Poradnik. *Edukacja Biologiczna i Środowiskowa.* Wydanie specjalne. *http://ebis.ibe.edu.pl/docs/ebis-poradnik-2016.pdf*

Siporska, A. & Chrzanowski, M.M., (red). (2020). Household Science, Chemistry and biology of everyday life – the simplest explanation of phenomena around us. Warszawa: Robert Parma Fotografia

Sitek, M. & Ostrowska, E.B.(red.). 2020. PISA (2018). *Czytanie, rozumienie, rozumowanie.* Warszawa: Instytut Badań Edukacyjnych.

Spratt, D., Armistead, A. & Taylor, L. (2017). Breakthrough National Centre for Climate Restoration: *Implications Of Climate Change For Australia's National Security, Submission to Senate inquiry on climate change and national security*

MOTIVATION OF GIFTED STUDENTS FOR STUDYING SCIENCE

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Abstract

The work aims on finding novel possibilities for educating upper-secondary gifted or talented students. Historical and present usage of terms *gifted* and *talented* is discussed. The legal framework of the Czech Republic as well as different approaches to giftedness are reviewed. Partial results of the initial quantitative research covering college choosing factors are introduced. Further qualitative and quantitative research possibilities are presented.

In the first part of the work we describe the way how are gifted students in the Czech Republic found and identified. The process of creating an individual study plan is briefly summarized.

We are also taking into consideration the factor of various competitions and their influence on the students' choice of a university. The impact on changing the students' attitude to the education in a particular field is discussed.

Initial quantitative research was held in purpose of more precise formulation of the research questions of the dissertation thesis. The questionnaire survey was held in the cooperation with an outreach event in October 2019 at the Faculty of Science, Charles University. Total amount of 63 upper-secondary-school students participated in the research. Further qualitative and quantitative research possibilities are presented.

*Keywords:*giftedness, talented students, upper-secondary education

Introduction

Giftedness is a widely discussed topic among parents (Kocurová, 2019) as well as wide public (Výborná, 2018). However, terms *gifted* and *talented* are commonly confused in the debate. Furthermore, the definition of giftedness is not united among various countries and/or schooling systems.

Historical points of view on giftedness

Giftedness was studied through 20th century. First definition of giftedness (Terman et al., 1915) connected giftedness with IQ, stating that gifted child is child with IQ above two standard deviations from the average, which means above 130. This definition covers approximately 2 % of the population.

However, IQ test does not cover all areas of giftedness and its usage as the only tool for assessing children is therefore not considered as an example of a good practice (ČŠI, 2016). In the following years, the topic was continuously discussed. Terman itself came with a proposal, that IQ does not determine the *success* of an individual alone (Terman, 1959).

In 1978[1] Renzulli came up with a novel definition of giftedness:

"Giftedness consists of an interaction among three basic clusters of human traits — these clusters being above-average general abilities, high levels of task commitment, and high levels of creativity. Gifted and talented children are those possessing or capable of developing this composite set of traits and applying them to any potentially valuable area of human performance. Children who manifest or are capable of developing an interaction among the three clusters require a wide variety of educational opportunities and services that are not ordinarily provided through regular instructional programs." (Renzulli, 2011)

This definition does not work with IQ at all. Furthermore, Renzulli in the citation below describes, that there is a moderate number of

[1] The original article was reprinted by the same journal in 2011. As the historical article from 1978 is no longer aviabile, we cite the reprinted article.

pupils performing not at the top of testing scale who are, on the contrary, compensating that with higher amount of productivity.

"A sad but true fact is that special programs have favored proficient lesson learners and test takers at the expense of persons who may score somewhat lower on tests but who more than compensate for such scores by having high levels of task commitment and creativity."

Thus, recognising these children as gifted shall be considered as a good practice. In fact, Renzuli is bringing into light the matter of motivation as an important part of success of gifted pupils.

The Renzulli's definition became broadly accepted and is used widely in the everyday practice of child psychologists (ČŠI, 2016). However, there were some reactions to it stressing some other points of view. From the articles citing that I shall point out Gagné's work on the topic, which discusses the difference between giftedness and talent and speaks about the educational process itself (Gagné, 1985). He discusses Renzulli's model regarding the motivation of gifted children. Gagné clearly describes the problem of underachievers, who are, according to Whitmore, *"revealed by a marked disparity between intellectual ability and academic performance in one or more subjects"* (Whitmore, 1980). These underachievers are, according to Gagné, not included in Renzulli's definition of giftedness, which leads to reformulation of the definition itself. The reformulation is rather formal than radical, stating that there are gifted children, whose giftedness was due to unsatisfactory environment not able to manifest.

Gagné stresses out the importance of motivation as well as the environment surrounding gifted children. He sees giftedness as a competence to perform exceptionally in a particular domain. This competence, however, is needed to be transferred to a specific performance in a field by investing time to develop the skills. The exceptional performance is then reckoned as talent. That means reckoning children as talented implies he/she is also gifted. This, however, is not applicable vice-versa – some gifted children may not manifest their giftedness as they were not in stimulating environment.

The gifted children in Czech Republic

State authorities recognise two level of giftedness – "nadané dítě" (gifted child) and "mimořádně nadané dítě" (exceptionally gifted child). The definition of gifted child is very broad – the Ministry of Education, Youth and Sports of the Czech Republic states in their legislative documents as well as at their webpages that *"gifted child is an individual, who proved greater knowledge and abilities in a particular field than its peers."* (MŠMT, 2020) The definition of a talented pupil is also present on the webpage (however, not in the law), stating that *"Talented pupil manifests him/herself in a way that deepen his/her giftedness by independent activities (diligence, exceptional ability to focus and developing his giftedness)"* As we compare the definitions stated by expert authorities above with the ones officially presented on the state authority webpage[2], we may see they accept the Renzulli's model, although the definitions presented may look not so greatly formulated.

The definition of exceptionally gifted child can also be found in schooling legislation. The law (*Vyhláška č. 27/2016*, 2016) states, that *"an exceptionally gifted pupil is considered to be a pupil whose distribution of abilities reaches an extraordinary level with high creativity in the whole range of activities or in individual areas of mental abilities, movement, manual, artistic or social skills."* As this definition is not strictly determining the exceptionally gifted, the law further specify the identification process: *"Diagnosis of exceptional giftedness (...) is performed by a site of education counselling centres in cooperation with school the pupil is attending. If the exceptional giftedness manifest in the field of artistic, manual, or physical activities, (...) the level of giftedness is assessed by an expert in the field."*

The exceptionally gifted pupils have a possibility to be educated according to individual study plan, which fits better to their needs. They can be also after an examining process reassigned to a higher grade. Issuing the individual study plan is in the competence of

[2] The definitions are present only in Czech, translation of them were done by the authors of this article.

school headmaster, who is obliged by law to consult it with education counselling centre and with parents of the pupil. The decree cited above further describes, what the plan should contain.

Reality of gifted or talented in the Czech Republic

The realisation of the measures being taken to help the exceptionally gifted can be viewed from another source – National Standard of Diagnostics of Exceptional Giftedness (Durmeková, 2018). This document, issued by the National Institute for Education for internal use, helps to unify the exceptional giftedness identification process. The document says in its preface, that schools may not be able to provide an adequate support for developing the giftedness. Furthermore, the importance of appropriate free-time (after-school) activities is stressed out. The document states that "*teacher should encourage the pupils to attend various competitions (...) and let them present their work on their own topic, so that they can manifest their giftedness in a field which is at or even behind the edge of interest of the school.*"

Attending a competition can positively affect gifted pupil's motivation to further develop their abilities (Udvari & Schneider, 2000). We can distinguish between *other-referenced* and *task-oriented* type of competitions (Tassi & Schneider, 1997). The former describes competitions focused on beating the others – being the first at the result table; the latter focuses on challenging pupils' abilities instead. Udvari & Schneider further discuss the importance of task-oriented competition in the education of gifted children: *"We encourage educators and parents working with gifted children, and all children for that matter, to emphasize and reward task-oriented competitiveness, or the striving to improve, while reducing the emphasis typically placed on winning, especially when winning can be accomplished with relatively little effort."*

Despite the effort of the authorities, only a fraction of pupils gets diagnosed (ČŠI, 2016). Taking that into mind, we shall not limit our research only to the diagnosed. Thusly, taking the expert definition as well as the Czech legislation framework into account, we decided to limit our research group of talented students in the way described below:

> ***Talented pupil (in a field) is a pupil who successfully takes part in nation-wide and/or international competitions in the field.***

This definition is broad enough to include all relevant pupils, as they are various nation-wide competition in our field of interest, such as KSICHT (Řezanka et al., 2013), Chemistry Olympiad (Fung et al., 2017), SOČ (NIDV, 2020) and Chemiklání (Alumni scientiae bohemicae, 2020). The teachers are advised to persuade talented pupils to attend these events (Durmeková, 2018), so we do not see the limitation of the research group as major.

Choosing a University - Questionnaire

The environment surrounding pupils during their upper-secondary education can affect their choice of a university. To determine the importance of individual factors influencing the choice as well as to get better insight into the mindset of pupils we designed a small-scale preliminary quantitative research. A brief questionnaire was distributed to all student participants of an outreach event *"Cesta do hlubin studia chemie"* which was being held from 28th to 29th October 2019 at Faculty of Science, Charles University, Prague. We distributed 67 paper questionnaire forms, we got back 63. The turnover is 94 %.

In the first part of the questionnaire we asked for basic sociodemographic data, like gender and age. Then we asked about the desired field of study – the participants evaluated their willingness to study a field on 1-10 Lickert type scale. Then we asked about some factors influencing their choice of a university.

The attendants of the event were selected on first come first served basis. We sent an invitation to over 600 schools in our database, pupils then enrolled via their teachers. We take in mind that the research group does not include only the talented, as well as the size of the research group may be too small to be representative. Therefore, we shall not generalise these results; we use them rather to optimise the questionnaire for future research.

Results and Discussion

Despite that, we can see some interesting trends in the data. Firstly, a large fraction of attendants was strongly motivated to study medicine On 1-10 scale assessing their willingness to study medicine 18 participants (29 %) chose 1, another 14 participants (22 %) chose 2. If we look at willingness of these pupils to study chemistry, we may see, that for a large number of participants, chemistry serves only as a second-choice field in case they would not be admitted to study medicine. That demonstrates Table 1.

Tab. 1. Willingness to study chemistry for aspiring medics

Willingness to study chemistry / **Willingness to study medicine**	1	2	3	4	5	6	7	8	9	10
1	6	2	7	2	0	1	0	0	0	0
2	0	7	3	0	2	1	1	0	0	0

Regarding the factors influencing the choice of the university, we found that the participants do not see enrolment of their friends to the same school as important. On 1-10 Lickert-type scale of which 1 means *very important* and 10 *not important*, the average mean on that question was 7,4 (median 8). Other factor not influencing the student's choice of a university was the presence of an entrance exam (average 6,2, median 6,5). The students were unsurprisingy mostly influenced by the available field of study (average 1,39, median 1). The second most influencing factor was the public prestige of school (average 3,9, median 3,5). Quite surprising was not so great interest in school publication outcome (average 4,6, median 4).

These results are highly influenced by the fact that many students are in fact future students at medical schools. We must admit that the giftedness of these students was not examined in any way. However, the realisation of this preliminary research guided us to redesign our questionnaire in some ways: we narrowed the scale from interval 1-10 to 1-7, we reformulated some of the questions to make them clearer and added a few questions to help us to further see the pupils' source of motivation.

As we described in the previous parts of this article, there is not a clear consensus on the usage of terms *gifted* and *talented*. The identification of the gifted is leaving majority of children undetected (ČŠI, 2016), which led us to a novel way of thinking about this. As pupil are and should be encouraged to take part in nation-wide competitions (Durmeková, 2018), we find it reasonable to limit our research group of the gifted children to the participants of various competitions. However, a control research with random research group representative enough to cover the students of Czech grammar schools *(gymnázia)* will be held.

The profile of the gifted children will be further studied by a qualitative research. This research shall be held in form of a structured interview. We shall further investigate, what are the possibilities to motivate gifted pupils to take part in non-compulsory education aimed at them and what type of study materials support education of gifted students the best way.

Conclusion

In this article we summarised current views on giftedness and gifted children. We discussed various past and present points of view on giftedness. We also presented the current state of dealing with the gifted and talented children in the Czech Republic, pointing out the importance of extra-curricular activities in their development.

In the last part of this article we presented some results of the preliminary quantitative research on the topic. The results, however, should be interpreted with caution, as the number of gifted students in the research sample is not well defined. To understand the matter more deeply, intensive research shall be held in the next years.

References

Alumni scientiae bohemicae. (2020). Chemiklání [Online]. Retrieved 2020-07-16, from http://chemiklani.cz/

Česká republika. Vyhláška č. 27/2016: o vzdělávání žáků se speciálními vzdělávacími potřebami a žáků nadaných, 2016Sbírka zákonů (Česká republika 2016). Praha: Tiskárna Ministerstva vnitra.

ČŠI. (2016). Vzdělávání nadaných, talentovaných a mimořádně nadaných dětí a žáků. Praha. Retrieved from https://www.csicr.cz/cz/Dokumenty/Tematicke-zpravy/Tematicka-zprava-Vzdelavani-nadanych,-talentovanyc

Durmeková, S. (2018). Standard komplexní diagnostiky mimořádného (intelektového) nadání. Praha: Národní ústav pro vzdělávání. Retrieved from http://www.nuv.cz/t/nadani/standard-komplexni-diagnostiky-mn

Fung, F., Putala, M., Holzhauser, P., Somsook, E., Hernandez, C., & Chang, I. (2017). Celebrating the Golden Jubilee of the International Chemistry Olympiad: Back to Where It All Began [Online]. *Journal of Chemical Education*, *vol. 95*(issue 2), 193-196. https://doi.org/10.1021/acs.jchemed.7b00640

Gagné, F. (1985). Giftedness and Talent: Reexamining a Reexamination of the Definitions [Online]. *Gifted Child Quarterly*, *vol. 29*(issue 3), 103-112. https://doi.org/10.1177/001698628502900302

Kocurová, L. (2019). Nadané děti potřebují výchovu stejně jako ostatní a není to s nimi někdy jednoduché, říká americký neuropsycholog [Online]. Retrieved from https://www.rodicevitani.cz/premyslive-deti/nadane-deti-potrebuji-vychovu-stejne-jako-ostatni-a-neni-to-s-nimi-nekdy-jednoduche-rika-americky-neuropsycholog/

MŠMT. (2020). Nadaná mládež [Online]. Retrieved from https://www.msmt.cz/mladez/talentovana-mladez

NIDV. (2020). Středoškolská odborná činnost [Online]. Retrieved 2020-07-16, from https://www.soc.cz/

Renzulli, J. (2011). What Makes Giftedness?: Reexamining a Definition [Online]. *Phi Delta Kappan*, *vol. 92*(issue 8), 81-88. https://doi.org/10.1177/003172171109200821

Řezanka, P., Šimůnek, O., Zajícová, M., Míka, L., Bartoň, J., & Řezanka, M. (2013). Fast and Attractive Chemical Education: A Chemical Competition for High School Students in the Czech Republic [Online]. *Journal of Chemical Education*, *vol. 90*(issue

10), 1259-1262. https://doi.org/10.1021/ed300882z

Tassi, F., & Schneider, B. (1997). Task-Oriented Versus Other-Referenced Competition: Differential Implications for Children's Peer Relations [Online]. *Journal of Applied Social Psychology*, *vol. 27*(issue 17), 1557-1580. https://doi.org/10.1111/j.1559-1816.1997.tb01613.x

Terman, L. (1959). *Genetic Studies of Genius: The Gifted Group at Mid-Life*. Stanford, CA: Stanford University Press. Retrieved from https://archive.org/details/giftedgroupatmid011505mbp/page/n7/mode/2up

Terman, L., Lyman, G., Ordahl, G., Ordahl, L., Galbreath, N., & Talbert, W. (1915). The Stanford revision of the Binet-Simon scale and some results from its application to 1000 non-selected children [Online]. *Journal of Educational Psychology*, *vol. 6*(issue 9), 551-562. https://doi.org/10.1037/h0075455

Udvari, S., & Schneider, B. (2000). Competition and the adjustment of gifted children: A matter of motivation [Online]. *Roeper Review*, *vol. 22*(issue 4), 212-216. https://doi.org/10.1080/02783190009554040

Výborná, L. (2018). Máte doma malého génia? Odbornice radí, jak poznat nadprůměrně nadané dítě [Online]. Retrieved from https://radiozurnal.rozhlas.cz/mate-doma-maleho-genia-odbornice-radi-jak-poznat-nadprumerne-nadane-dite-7674942

Whitmore, J. (1980). *Giftedness, conflict, and underachievement*. Boston: Allyn and Bacon.

FUEL CELLS HYDROGEN EDUCATIVE MODEL GOES TO SCHOOLS – FIRST RESULTS ARE ENCOURAGING

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Abstract

Weather (and football) are subjects where more specialists exists than citizens. The social awareness concerning climate changes ranges from complaints about scientists "that do not understand simple things that my grandmother already knew" to worldwide strikes of young people against global warming. The FCHGo Project was created to move past these two extremes: it is meant to demonstrate the necessity and technical solutions for not only mitigating climate changes and local urban pollutions, but to for changing our way of thinking at the very basic level, starting from early primary school.The difference between this and many other approaches to teaching about climate, regenerative energy, and hydrogen technologies is that we insist on understanding the concepts of energy conservation, energy carriers, and energy dissipation. We do this by using a narrative approach, via simple stories children can understand, that refer directly to nature (a story of an apple, an animated story of a perpetuum mobile, etc.), and interactive, simple experiments. The project involves Italy, Germany, Switzerland, Denmark and Poland: in each country the social awareness and the technological needs are different, so have created targeted contents. In didactic experimentation to date, the involvement of teachers and the enthusiasm of pupils contributing with their drawings, stories, and spontaneous playing with experiments is strongly encouraging.

Keywords: fuel cells, hydrogen, energy, experiments, hydrogen cars

Introduction

Weather (and football) are subjects where more specialists exists than citizens. The social awareness concerning climate changes ranges from complaints about scientists "that do not understand simple things that my grandmother already knew" to worldwide strikes of young people against global warming. The EU funded "Fuel Cell Hydrogen Educational Model Goes to Schools" (FCHgo) Project was created to move past these two extremes: it is meant to demonstrate the necessity and technical solutions for not only mitigating climate changes and local urban pollutions, but for changing our way of thinking at the very basic level, starting from early primary school.

The difference between this and many other approaches to teaching about climate, regenerative energy, and hydrogen technologies is that we insist on *understanding* the concepts of energy conservation, energy carriers, and energy dissipation. We do this by using a *narrative* approach, via simple stories children can understand, that refer directly to nature (a story of an apple, an animated story of a perpetuum mobile, etc.), and interactive, simple experiments (Volta's batteries and hydrogen toy cars).

The project involves Italy, Germany, Switzerland, Denmark and Poland: in each country the social awareness and the technological needs are different, so have created targeted contents. In didactic experimentation to date, the involvement of teachers and the enthusiasm of pupils contributing with their drawings, stories, and spontaneous playing with experiments is strongly encouraging.

Here we describe FCHgo contents and methods, which are based on narrative principles – interactive discussing and common, with pupils, solving questions. We give also first didactical results, both as introducing the novel methodology, as well - and even more decisive – in rising social awareness among youth people on the necessity of technological transformations in the field of energy "resources", their sustainability and environment cleanness.

New “sources” of energy for XXIst century

The European didactic project FCHgo! - Discover the energy of hydrogen brings energy issues into European classrooms by supporting hydrogen and fuel cell education in schools. The issue is extremely important from the technological and social point of view. The nineteenth century was the age of the steam engine, the twentieth century was the era of the domination of the internal combustion engine, while the twenty-first century will probably be the age of the fuel cell. FCHgo is a European project dedicated to fostering knowledge about fuel cell and hydrogen technology by delivering an educational model for schools.

The project invites pupils and their teachers alike to discover the energy of hydrogen with innovative teaching materials and along inspiring activities in classrooms and beyond. The aim of the Project is to raise public awareness through didactic and popularizing activities in the field of:

– climate change,
– alternative „sources” of energy,
– hydrogen technologies, in particular fuel cells.

The FCHgo project was supported by the European research and innovation program Horizon 2020 under the aegis of Fuel Cell and Hydrogen Joint Undertaking (FCH JU). A two-year project that started in January 2019 is coordinated by Università Modena Reggio Emilia in cooperation with InEuropa srl Italy, Zürcher Hochschule für angewandte Wissenschaften, Technical University of Denmark, Nicolaus Copernicus University and Steinbeis 2i GmbH. In the FCHgo project, scientists, experts and teachers in science education work together to inspire students and teachers to both use hydrogen and the importance of its potential role as an energy source. FCHgo project! brings energy into European classrooms by supporting hydrogen and fuel cell education in schools.

Hydrogen is the most abundant element in the Universe and is a clean energy carrier, but the possibility of using H_2 energy is a rarely discussed topic in school. Even simple experiments with hydrogen as a chemical element are rarely run in schools. To support energy education in schools, the EU FCHgo project proposes an innovative teaching concept, based on narration, and multimedia materials that inspire teachers, students and their parents to know about the world of hydrogen energy, or even more, quoting Jerome Riffkin – "Hydrogen economy".

The project is a practice-oriented set of educational exercises for interactive lessons on fuel cells and hydrogen. FCHgo develops a set of learning activities tailored to teach students aged 8 to 18. The kit includes games, stories, scenarios and experimental kits that visualize how energy processes work and inform students about the various uses of hydrogen. To ensure that the materials are well suited to educational practices and draw on the latest FCH research and industrial development, FCHgo partners will engage a wide range of stakeholders from education, science and industry. FCHgo project will contribute to the broadly understood science of energy by proposing a narrative and innovative approach to teaching FCH. The aim is not only to impart knowledge about fuel cells and hydrogen, but also to stimulate students' interest and open their minds to the world of science.

Narrative didactics on energy and hydrogen

Social awareness on environmental issues and the state of technological development of alternative energy "sources" differs much, say between Poland, with economy still based on carbon and Denmark, obtaining a quarter of the national electricity from wind. Therefore, we present a vast approach that include both on-line presentations and simple interactive experiments on energy, electricity, hydrogen and fuel cells.

The novel approach consists, from the formal point of view, in treating physical concepts like the energy, momentum, chemical potentials as flow diagrams. This kind of diagrams makes clear that the energy is not "produced" but changes forms: the left and right side of diagrams are always in parity. In fig. 1. we present such a diagram explaining formally the processes in hydrogen fuel cells. The diagram shows the flows – of the two "energy carriers" of the chemical type. i.e. hydrogen and oxygen on the left side and the electrical current produced on the right side. A missing part in the energy balance is the heat produced.

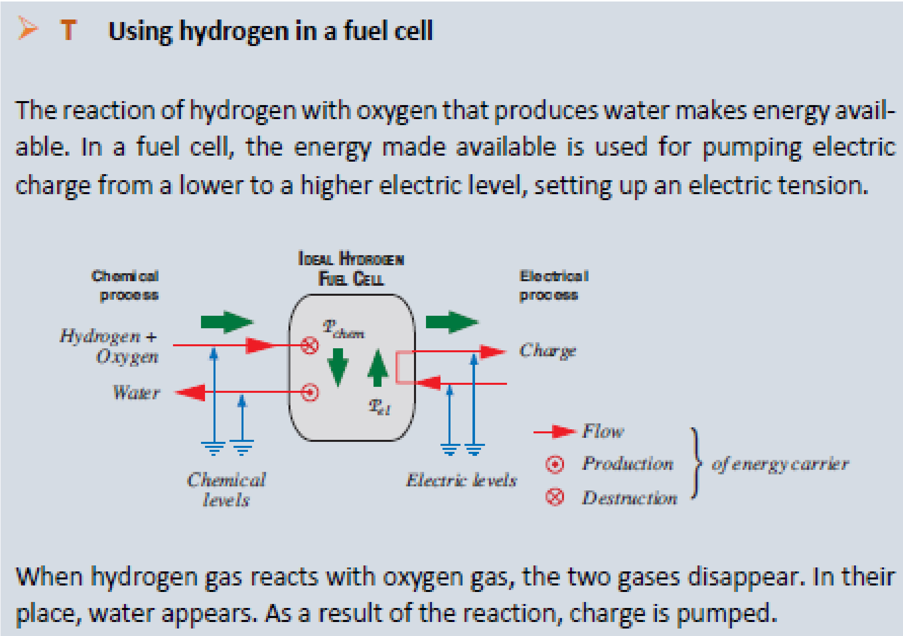


Fig. 1. The formalism explaining flows of the energy in a hydrogen fuel cell. From FCHgo didactical materials (Fuchs 2019).

Obviously, a fully formal approach is too much difficult to be explained to young pupils. Therefore, and this is the main challenge of the FCHgo, both the Project university staffs and teachers are involved in "translating" the very formal concept that the energy is conserved and not "produced" into easy to understand and appealing to children imagination pictures, games, videos. An example is shown in fig. 2.

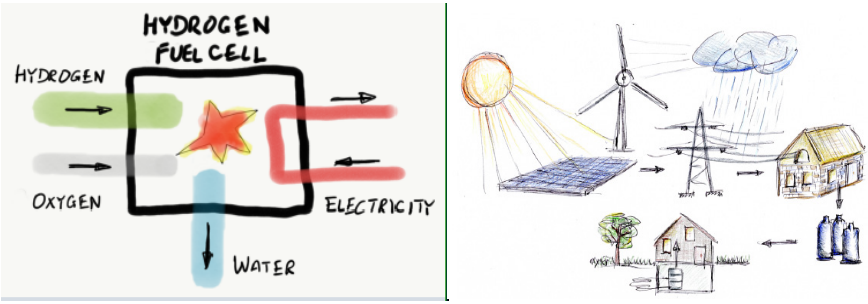


Fig. 2. Easy-to-understand pictures explaining concepts of energy transformation and "alternative" energies. From FCHgo material by H.U. Fuchs (2019), drawings by R. Fuchs.

First, it is important (for us, as physicists and biologists) to teach the laws of "conservation" – of the energy and matter: nothing appears from null and nothing disappears in null. We use notions of the energy carriers: their continuous flow is the essential notion. To explain it to children 8-10 years old, "An Apple Story" (Fuchs & Fuchs, 2019) has been prepared, see fig. 3. Not being able to use the term "energy forms" we speak about "forces" that contribute to an apple growing: sunlight (bringing the energy in the form of photons), water and "air" (in reality the CO_2) needed for the chemical transformation of hydrogen, carbon and oxygen into organic matter.

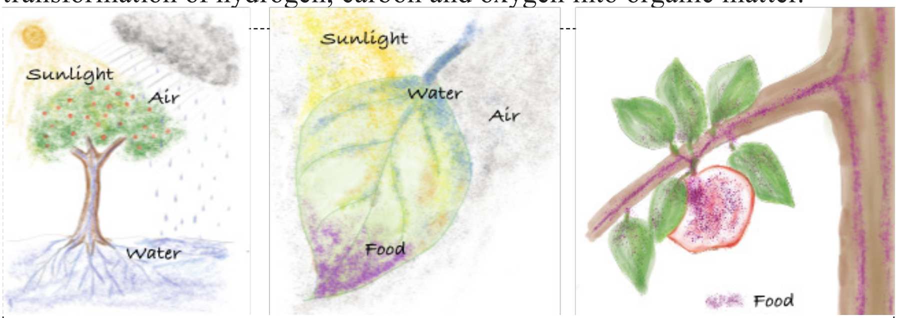


Fig. 3. Illustrations from An Apple Story. Left: A tree and three "forces", sunlight, water, and air. Center: The forces come together in a leaf where they will blend, fade away and create food. Right: The food travels to parts of the tree and into the growing apple. Selection from Dumont et al. (2019).

The narrative approach uses the resources of the common, informal language, to introduce the desired concepts of physics and chemistry. The knowledge is not given to students as ready notions but discussed together (Corni et al. 2019). An example of the metaphor and narrative approach on hydrogen technologies is shown in fig. 4.

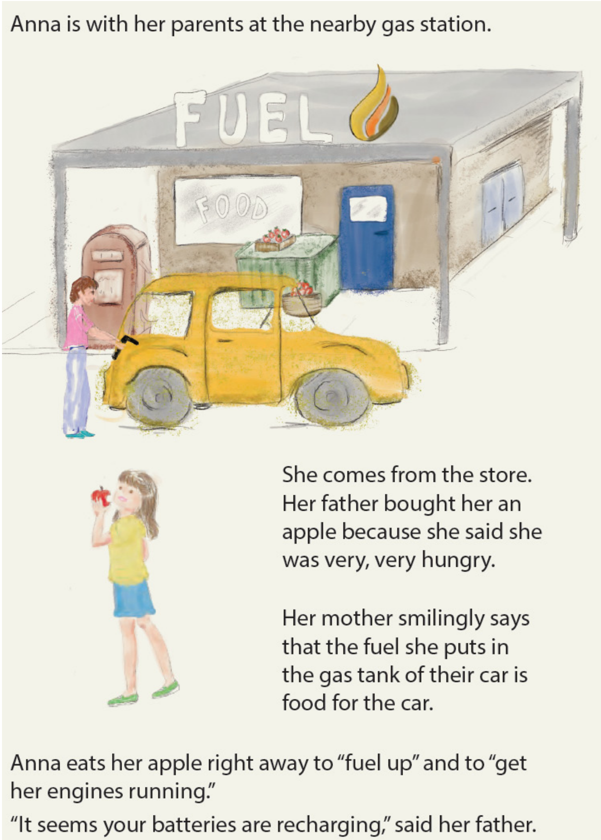


Fig. 4. The use of the common, informal language to explain the interdisciplinary concepts of energy transformation: from the chemical form (petrol, apple) into the kinetic energy and the heat (car) and all physiological activities (playing, speaking, reasoning) by Anna who eats the apple. The last sentence "the batteries are recharging" introduces indirectly the subjects of hydrogen fuel cells. Drawings by R. Fuchs, from "An Apple Story" (Fuchs & Fuchs, 2019).

Similarly easy-to-understand but surprising in concept is the video story on "Perpetuum machine" by Marion Deichmann [5], prepared under the scientific supervision by H. Fuchs. It starts from an old dream of endless chain of energy transformations, but expanded into modern forms: photons form a lamp, photovoltaic cells, electric dynamo. The story starts from the force of a hand which puts into motion the dynamo. Different carriers of energy are illustrated by colorful "ghosts" that sleep or move when they bring the energy flow.

The conclusion from the video is that without an external source of energy the whole cycle is not possible. But when sun shines as such a source the whole cycle of energy transformation goes for ever (as long as sun illuminates the machine…)

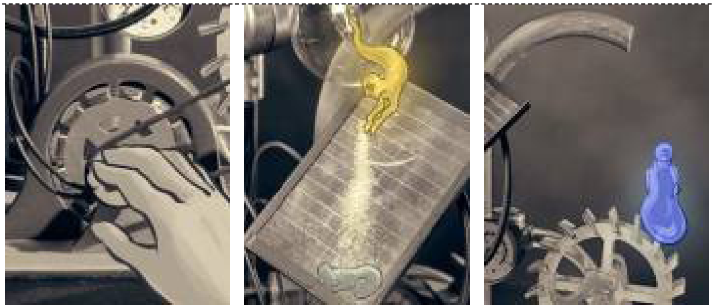


Fig. 5. Initially, the inventor drives the generator of the Perpetuum Mobile machine by hand. Light drives the solar cell, a pump pumps water high up whereupon it falls down. There are "ghosts" or "spirits" at work in the machine which play an important role later in the story told here. From Deichmann (2014).

To complete the set of the narrative material an energy card game has been prepared. Students exchange cards that illustrate different forms of energy – like in a physical process, see fig. 6.

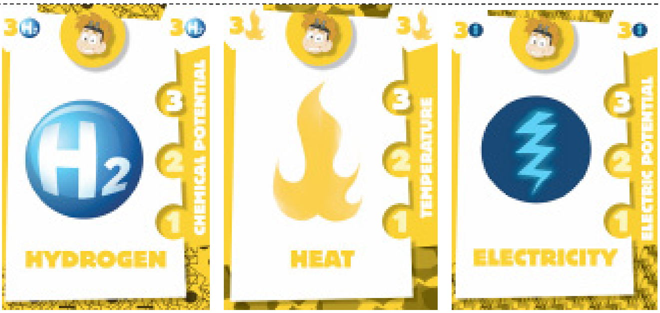


Fig. 6. Cards representing forces of nature (as energy carriers) made available through Ergoland. Left: The card developed for hydrogen (like every card, it displays three possible levels, i.e. potentials). Middle: The card developed for heat. Right: The card developed for electricity.

Different elements – "Perpetuum mobile" video, the interactive experiments with electrolysis, diagrams of processes and elements of fuel cells are incorporated into teaching scenarios, see fig. 7. In schools that volunteered for testing a series of four meetings with experts, each meeting of two hours was proposed.

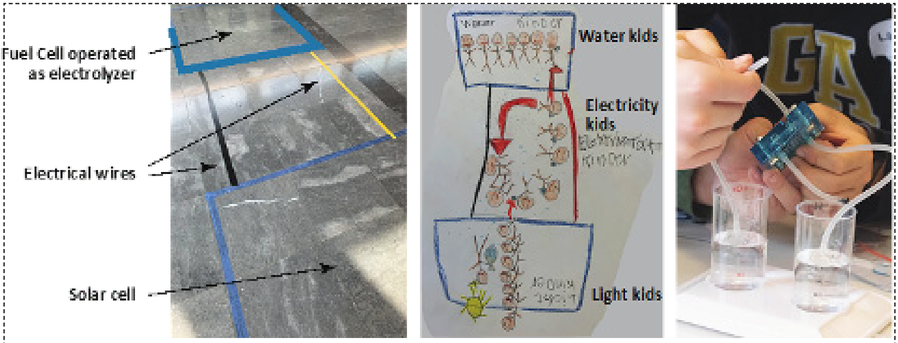


Fig. 7. A primary school class in Switzerland (2nd graders) play forces of nature acting and interacting in a lamp-PV-cell-electrolyzer system. Left: The floor with an outline of solar cell (bottom) and electrolyzer (top) with the paths (cables) for electricity between them. Center: A drawing by a child made after playing the Forces-of-Nature Theatre. Right: Part of the physical laboratory preceding the activity.

Before running lessons in selected schools we prepared teachers. In 2020 lessons started that involved c.a. 900 students in 5 countries. However, national differences required some modifications of the didactical material.

National contents

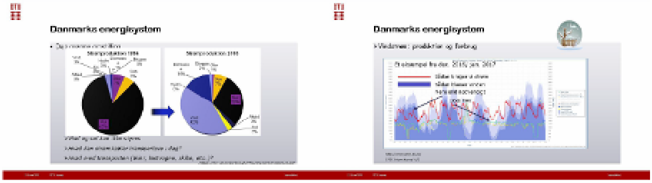
As already said, specific social contexts in different states force us to adopt slightly modified contents for teaching in, say Denmark, Germany and Poland, see fig. 5. below. In Denmark in twenty years 2004-2016) the coal has been substituted by wind as the source of electricity. However, the wind does not guarantee a constant level of the delivery of electricity. As far as other countries use other energy sources (for ex. the nuclear one), it is possible to compensate the fluctuation. A study by the German Association of Hydrogen (middle panel in fig. 8) shows a similar mismatch in delivery and consumption of the electricity in Germany: there are not currently any capacities of the energy storage to compensate periodical shortages. For Poland the main problem is the predicted deficit in the production of electricity (due to finishing resources of coal) that without any structural changes may reach 30% of the demand in 2040. At the same time the air pollution in Poland (monitored as benzopirene) exceeds by a factor of 10 the level in the rest of Europe, see our didactical paper in Polish "Physics in School" (Karwasz et al. 2019).

D3.3 – First report on educational outcome

Version 2.0

3a. National priorities

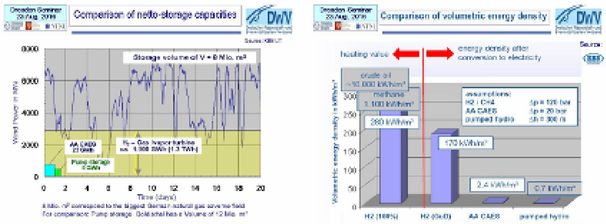
As specified above, the educational material has been adopted to specific national priorities. In Poland this is a huge air pollution due to burning coal. Denmark has in last 20 years converted a large part of the energetic system from burning coal to wind-generators. But this, in turn, creates problems with energy storage: electricity production, hour by hour, do not meet the consumption needs. So the storage of hydrogen obtained from electrolysis of water would be an important part of the national system, see pictures below from lesson prepared by prof. Anke Hagen from DTU.



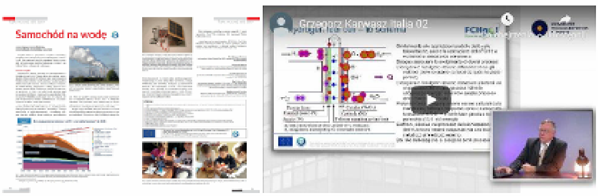
(a) Energy "production" in Denmark in 1994 and in 2016: black is coal, blue is wind. (prof. A. Hagen)

(b) The demand and supply of energy, day per day in Dec. 2016: they do not meet each other.

Also in Germany it is well understood the need for new energy policies: productions and storage. Here below we present two pictures from a comprehensive lecture for an international consortium, held in Dresden on August 22[nd] 2017, by dr Johannes Töpler, from Deutscher Wasserstoff und Brennestoffzellenverband (DWV).



Two pictures from presentation by dr J. Töpler (DWV) showing: (a) mismatch between wind power and energy storage capacities, (b) storage capacities in water basins, in oil tanks, methane and hydrogen underground tanks. Courtesy: dr J. Töpler.



Additional educational/ dissemination material produced at UMK: (a,b) "Water driven car" - a paper published in *Physics in School* (1[st] and 6[th] page). (c) Series of 5 lessons registered in Italian (and Polish) for secondary schools - teachers and students. Lessons No. 4. "Hydrogen fuel cell", https://youtu.be/dlbEz0OMEMU

4. Current activities in schools

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Fig. 8. The national differences in FCHGo: In Denmark and Germany the main macroeconomic problem in energy policies is to create some storage margins, in Poland – the challenge is to substitute coal with other energy "sources".

Activities in schools

In the first part of the Project, with the didactical material still in preparation (and translations) lessons in different countries followed somewhat different scenarios. In Poland we concentred on rising the social awareness on the global warming and the atmospheric pollution (in secondary schools) and on the phenomena of electricity and hydrogen in primary schools. In Switzerland (and Italy) lessons in primary schools followed more strictly the metaphoric approach, as children had already some notions on the electricity. As seen from fig. 9, the lesson (run by ZHAW expert Erwin Hounder) at the 4th grade of primary school Winterthur was based on "ghosts" to explain the energy fluxes and transformations.

Fig. 9. Narration and metaphor used in teaching on hydrogen, sun and energy carriers in elementary schools in Switzerland (Winthertur, January 2019). Teacher Erwin Hounder.

Fig. 10. Activities in classes 1st & 2nd (7-9 yrs old) in primary schools in Dąbrowa Biskupia and Ośniszczewko (Dec.2019). Teacher: Katarzyna Wyborska.

In turn, in Poland, pupils enjoyed much simple experiments with electricity (batteries, photovoltaic cells, models of hydrogen-driven cars.

In secondary schools (in Poland and Italy) we used Power Point presentations and sets of more complex experiments in the electrolysis, hydrogen fuel cells, thermodynamic engines, photovoltaic cells etc, see fig. 11.

Fig. 11. FCHgo activities in secondary schools in Poland: (a) First lesson with experts in LA Słupsk, 18/10/2019 (G. Karwasz, A. Kamińska) – introduction to environment and energy problems. (b) Alternative energies – interactive experiments (IX LO Gdynia, 22/11/2019); teacher T. Bury, experts A. Kamińska and G. Karwasz. (c) Reception by students (54 persons) I LO Gniezno 25/20/2019; expert G. Karwasz

In total, almost 1400 pupils followed FCHgo lessons. Unfortunately, due to the unpredicted events, in March teaching in classes was interrupted. Some of the material has been delivered on-line, but we missed the completeness of the scenarios.

Preliminary didactical results

Generally, both teachers and pupils were quite enthusiastic about the new didactical approach and specific contents on hydrogen technologies. FCHgo lessons showed that the young generation is already sensible about environment problems but does not see clear solutions.

Post- lessons tests of knowledge in Polish secondary schools showed that “students know quite a lot on the problems of environmental pollution, on climate changes, thay know in what these changes consist, what they are caused by. They also know that urgent actions must be undertaken, but they do not know what they can do themselves to mitigate environmental pollution. They ask when hydrogen cars will circulate on urban streets.” (dr Anna Kamińska)

Narrative approach was highly appreciated in Italy, where teachers had met it some time before the start of FCHgo Project. Dr Paola Morelli (UNIMORE) commented it:

“The narrative and metaphorical approach on energy has been successful for younger pupils. The Apple story, the Perpetuum mobile video, Card and role playing games and the Fuel cell model car were helpful to raise interest and involvement in scientific topics, especially for alternative energies and fuel cell hydrogen. Nevertheless, some materials have to be adapted to the age of older pupils (13-14 yrs old).”

The FCHgo material proved to be a little but too complex for German teachers (that did not follow the same rate of preparation as Italian ones. One of the German teachers commented:

“In my opinion, the learning process in general is too ambitious for the expected age group. The materials can only be used in parts in this way in the classroom or require their own additions. Approaching the topic through the story and making it experienceable through the role play is well accepted. The film and the other materials are sometimes simply too far beyond the children’s comprehension, which is why they cannot be used as support material. Unless you live with the fact that only the fitter children come along. Therefore, a lot of time and work has to be invested by the teacher to develop material that can be used for support. With the materials available the students have problems to understand the content in its full dimension. That is a shame!

The technical content is exciting, highly up-to-date and could be explained to the target group in a simpler way or the target group could explore it in basic principles. For this purpose, information material would be helpful, which does not have to be broken down first. This requires additional time, which a teacher whose main focus are non-scientific subjects can hardly afford.” (Sandrina Felder, Augsburg).

Another teacher (Ulrike Krämer) writes:

“The methodological content is varied and involves the children to a high extent. However, the material forces the teacher to be in the centre of the learning process and to guide it to a large extent. Here a shift to the pupils themselves would be helpful and would promote personal responsibility and independent learning. Material with simple steps and possibilities for self-checking would make this possible."

At the level of secondary schools students were generally much interested and enjoyed in particular interactive experiments. The test performed were multi-choice, but on purpose constructed with no unique correct answer. In consequence, students had some difficulties, as seen from the example below (numbers in parenthesis show the number of students who signed this answer)

B. What is the main advantage of using hydrogen in fuel cells? Choose the best answer.

1. Hydrogen is cheap to be produced. (4)
2. Burning hydrogen does not emit CO_2. (26)
3. Efficiency of fuel cells is, potentially, higher that burning hydrogen in combustion engines. (14)
4. Fuel cells are simpler in construction than combustion engines. (2)

As far as the goal of inducing an own reflection among students was achieved, we lacked the clarity of the didactical message: in the example above we hoped to obtain the majority of answers in point, as the hydrogen fuel cells do not burn hydrogen but perform the chemical synthesis of H_2O. The conclusion is that we must underline better the main points of hydrogen technologies.

In late spring 2019, during lock-down, some activities were proposed on-line. In fig. 12 we show on-line answers of elementary school pupils on photovoltaic cells and hydrogen technologies.

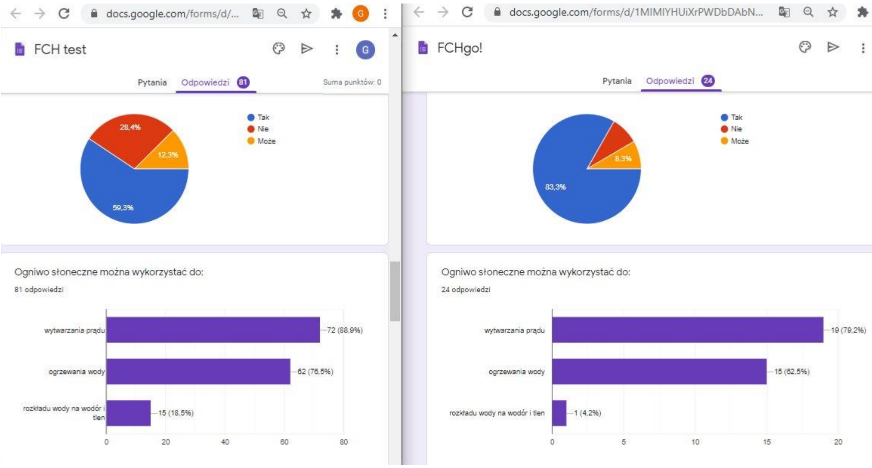

Fig. 12. On-line tests of the didactical outcome of FCHgo lessons in Poland: pupils "trained" from Dąbrowa Biskupia and Ośniszczewko (81 persons, left panel) are compared with 24 pupils who accessed the site on the voluntary basis (right panel). Two chosen questions are shown. The pie graph answers to the question "Is hydrogen a renewable source of energy?": blue – yes, red – no, yellow – maybe. The bar graph shows answers to the question "For what purposes a photovoltaic cell can be used?": upper bar – to produce electricity, the middle – to heat water, lower bar – to make electrolysis of water into hydrogen and oxygen. Essentially, only pupils "trained" in FCHGo recognize the link between PV cell and hydrogen (in the control group, right panel only one person gave this answer). Author of the test and internet interface – K. Wyborska, May 2020.

Contributions from teachers

The narrative approach was developed in Italian-Swiss university collaboration and as a such implemented in FCHgo didactical model. What is the real added value in the EU-based project is the contribution from other participants, especially teachers, who an a long-run should learn the new methods and contents. Questions asked by one of us (KW) in the environment of a small rural schools in Poland are as follow:

- Why alternative and hydrogen technologies are important?
- Why it is important to teach them in the school?
- Why it is important to teach them in rural schools?

There are many reasons for teaching about renewable energy and hydrogen cells. In first place our students should be equipped with knowledge that will allow them to respond to the needs of the current market and economy. Pupils should know the benefits of renewable energy and hydrogen technology. The most important aspect is taking care of our natural environment. By using renewable energies, we can have a better impact on our environment and reduce smog which has a negative impact on our health. This kind of lessons make a major contribution to promoting the environmental awareness of students. We need to talk about climate change in schools and how it can affect the lives of future generations. We have to convey to students that obtaining energy from sources such as coal or oil has negative and often irreversible effects on our climate. Reliable transferred knowledge on this subject allows to explain the complex physical phenomena occurring during energy transformation, as well as the advantages and disadvantages of these technologies.

An important element in teaching is to show how the use of renewable energy or hydrogen looks like in practice. For this purpose, we use photovoltaic panels, wind turbines, and a hydrogen-powered car. Such methods of conducting classes, used as a tool for developing key competences, are an example of diversifying a standard lesson in physics, technology, nature and a departure from traditional teaching. The obvious argument is to shape critical, logical thinking, planning, reasoning, arguing and anticipating future decisions.

Introducing teaching about renewable and hydrogen energy gives the opportunity to shape the key competences and ecological culture of students from rural areas. The implementation of the FCHgo! project made a huge contribution to energy education in primary school. The proposed teaching concept allowed to inspire students to deepen their knowledge of climate change, renewable energy sources and hydrogen technology. All activities undertaken within the framework of the project had a common goal, supporting the development of students of the school, shaping research attitudes and competences through discovery.

Thanks to such solutions, the school provides access to information that may influence the further choice of educational path or future career. We invite students and teachers to discover hydrogen energy through innovative methods and educational materials to inspire activity in the classroom and beyond.

Conclusions

The Projects, still running, already showed that basic principles of FCH functioning can be easily understood even by youngest pupils. The impact consist in important aspects of school education, ensuring young minds are adequately prepared for the energy policies, so that ecological thinking becomes an integral part of their lives. The Projects brings also benefits introducing new didactical methods, interesting for teachers. The use of metaphor, the narrative approach, and interactive experiments proved to bring the real didactical novelty. Finally we must stress the high social impact in rising pupils consciousness on the environmental problems and giving information on possible technical solutions, hydrogen technologies in the first place.

Acknowledgements

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References

Corni, F., Fuchs, H U, Landini, A. & Giliberti, E. (2019). Visual and gestural metaphors for introducing energy to student teachers of primary school and kindergarten levels. *Journal of Physics:*

Conference Series, 1287 (2019) 012043.

Deichmann, M. (2014). Im übertragenen Sinne. Metaphern und Bildvergleiche in der Wissernschaft. (Bachelor thesis) Zürcher Hochschule der Künste, http://vimeo.com/98311515

Dumont, E., Fuchs, H U, Corni, F., Contini, A., Altiero, T., Romagnoli, M. & Karwasz, G P. (2019). FCHgo: Fuel Cells HydroGen educatiOnal model for schools, an imaginative approach to hydrogen and fuel cell technology for young students and their teachers. GIREP

Fuchs, H U. (2019). Hydrogen and Fuel Cells. How, What for, and Why? FCHGo Project.

Fuchs, H U. & Fuchs R. (2019). An Apple Story. Didactical Materials FCHGo Project.

Karwasz, G., Wyborska, K., Kamińska, A., Karbowski, A. & Bury, T. (2019). Water-drive car. *Physics in School* (Poland), 363 (LXIV) nr4., 10-15.http://dydaktyka.fizyka.umk.pl/Publikacje_2019/2019_FwSz_samochod.pdf

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BREWING INDUSTRY IN THE TEACHING OF CHEMISTRY

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Abstract

The teaching of chemistry has recently been very curtailed by legislation and a low time subsidy. For today's pupils, chemistry becomes something hard to grasp and abstract. So practical exercises have been designed to promote the teaching of chemistry to link the chemical principles to the practice of everyday life for pupils. These exercises should then make pupils better able to navigate chemical principles, gain multidisciplinary interconnectedness and acquire basic practical skills of chemical practice. The theme of brewing was chosen in light of rich history and cultural interdependence. The great advantage of this topic is the complexity at which it touches on topics across the whole of chemistry. The basic principles of technology are easily demonstrable and financially inexpensive. The exercises are processed as projects that pupils implement for themselves. So it develops not only competencies for learning, but also for problem solving. So the aim of the exercise is to promote practical teaching in primary schools and grammar schools and to encourage pupils to study natural sciences.

*Keywords:*brewing, practical teaching, motivation, chemistry, support for practical teaching

Introduction

These days, chemistry lessons are built on theoretical teaching, naming, equations and chemical calculations. This is all absolutely necessary to dominate chemistry as a science field. However, by drilling in the form of name-calling, equations and theory, which for pupils is very abstract in them we can absolutely unintentionally kill passion for science as well. It is a general fact that interest in natural sciences has declined in recent years. But if we think about children or even our childhood, every child wants to be a mad scientist and have a mysterious laboratory. So by practising exercise, we can let children explore and make them curious and interested in the natural sciences. Brewing as a theme in teaching offers many benefits.

The first advantage is that everyone knows beer. It has a rich history in the Czechs are sort of generally connected to us. It has a long tradition in many regions to date, so its inclusion in teaching also deepens knowledge of its own region.

Brewing, however, may not only be associated with getting to know your own region, but with other related disciplines. This topic can also be associated with biology or physics, for example. So it also offers rich interdisciplinary links that point to the interconnectedness of all scientific disciplines, which pupils are sometimes oblivious.

Ingredients to make beer, which the following determinations are based on, can also be regionally accommodated. It’s obvious with water analysis. You can ask a local brewery or mini-brewery for malt and hops, of which there are plenty these days. As a rule, their owners don’t have a problem donating small amounts of hops and malt. Another advantage is the illustrative nature of the different methods.

These are methods that pupils can try. There are no extremely dangerous substances and the methods are not even particularly demanding for technical equipment. I deliberately prepared these demonstration methods so that they could be applied on the ground of a less equipped school.

Brewing theory

As we mentioned, the brewing practice is not demanding of raw materials or chemicals, so the basic ingredients are water, malt, hops and yeast. Furthermore, we will resolve only on the raw materials related to the model exercises mentioned here.

Water -_Brewing as an industry is one of the most demanding water consumers, with its consumption among the highest. We divide the water in the brewery into three groups:

Operational water - this water is adjusted according to its use. If it meets areas that subsequently come into contact with food, it must meet drinking water hygiene standards.

Washing and sterilizing water -- this water must be free of chemical and microbiological impurities - must not smell and is recommended to chlorine as opposed to boiling water.

Boiling water - is one of the basic ingredients in beer production. In beer, water is represented 75 to 80 % by weight depending on its species. Boiling water must meet drinking water hygiene standards in terms of health safety. Its quality and composition are significant importance on the resulting beer sensory, whether from a microbiological or physico-chemical point of view. (Basařová, 2010) In brewing, we divide water types according to hardness into water: Fully-soft water with a small proportion of inorganic ingredients is ideal for producing bottom-fermented and heavily hopped beers. (Basařová, 2010)

Munich-on the cusp of moderate-to-hard water, with little chloride and sulphate content, but more carbonates and calcium. (Basařová, 2010)

Dortmundian - very hard water, where noncarbonate hardness outweighs carbonate hardness. (Basařová, 2010)

Vienna's - very hard water, where, on the contrary, carbonate hardness dominates over non-carbonate hardness water relative to Dortmund water. (Basařová, 2010)

Burton on Trent - water is very hard with a high sulphate content, used especially for the production of highly hopped, top-fermented Ale-type beers. The treatment of Burton's brewing water is done by adding calcium sulphate, so-called burtonization. (Basařová, 2010)

It is clear from the above list that the water used will differ in its composition in individual cases. This composition affects us not only the resulting taste, but also the so-called aggressiveness of the water. This aggression does not need to be discussed more deeply here, but of the ions affecting the sensory and properties of beer, we should remember the following in particular.

Hydrogen (hydroxonium) and hydroxide ions are of course present in each water and their ratio affects its pH. Calcium, magnesium, sodium, potassium, manganese, copper, zinc, aluminum, tin, lead, sulphate, chloride, fluoride, nitrate ions affect both taste and, for example, subsequent foaminess, yeast activity or the colour of the wort. (Basařová, 2010)

All ions could be discussed in more detail, but it is particularly worth noting for children nitrite ions, which indicate microbiological and ammonium pollution indicating organic contamination. For a practical demonstration, we then use the example of ferrous and ferric ions causing slowing of the saccharification of mash, discoloration of wort and foam and degenerative changes of yeast. They also strongly influence the taste of the beer - the heavy metallic flavor and reduced fullness of the beer.

In addition to the ions we have named, however, there are also dissolved gases in the water, and even these affect the resulting product of the brewing process. In natural water we can find carbon dioxide, oxygen and sulfan in particular. It is a good idea to mention this to children, gases affect water corrosion, for example, and in the case of said chlorine, the resulting product, in fact, chlorine is toxic to yeasts and therefore does not ferment properly. (Basařová, 2010)

Malt - Malt means a technologically processed variety of malted barley. This has to go through specific technological processes. This will change the ratios and substance content of the grain to its improved technological yield. For the best possible yield, special varieties are bred, we grow malting and feed barleys. As a rule, malting barleys have better enzyme equipment. This also makes them more carbohydrate and lower in protein, which is central to the successful cooking process. (Basařová, 2015)

The basic brewing process consists of several stages: Scrapping, mopping, rmuting, scewing, hops, fermentation and final fermentation. All these stages have a large number of different variants of technological practices. Here we only mention the basic principles of the brewing process stages involved in model exercises for understanding their performance in the laboratory.

Mopping - the process where we mix the prepared scrap malt with water. In simple terms, we need to mix water with malt so that we don't damage the endosperm and its enzymes. Compliance with the correct mopping water temperature is essential, this is usually 37 °C. The work must be mixed throughout the mould to avoid local overheating and enzyme inactivation. (Kosař, 2000)

Rmuting - the principle is to convert all the substances into a solution. Only about 15-17 % of the extract is directly soluble in the grain and can be transferred to the solution by simply stirring. The rest of the grain contents must be split first. This is possible due to the presence of the enzymes already mentioned. Enzymatic activity is started by stirring in water and complying with the moulding temperature, which is 37 °C to kick-start the enzyme activity. Our goal is to split all the starch into units of glucose and the correct ratio of protein, and other substances. At the same time, we are trying to limit the amount of polyphenols from malt ploughs, for example. It is therefore absolutely crucial when rmutating to adhere to set temperatures, which very much influence the action of enzymes and therefore the efficiency of rmutation. (Kosař, 2000)

The cleavage of starch - starch is a complex polysaccharide in the base formed glukosami. Depending on its origin, contains 20 – 25 % amylose. This is composed of 60-600 glucose units. Amylosa is water soluble, and the effect of ,-amylasa is particularly splitting into maltose. Furthermore, starch contains 75 to 80 % amylopectin, which is also split into maltose and dextrin, but there is already a need for a common effect of the two amylas. Compared to amylose, which contains only bindings of α-1,4. Amylopectin contains bindings of α-1,6 on branched sections and contains around 3,000 glucose units. Amylopectin is insoluble in water on cold and up to an increasing lubrication temperature, so it is necessary to split it into a solution for successful transfer. (Basařová, 2010)

The process of splitting the starch into the maltose we require involves three stages: lubrication, liquefaction and saccharification (sugaring).

The lubrication stage occurs after the solution has been heated. Due to the increased temperature, the starch grains start to swell and then crack, releasing amylose and amylopectin into a solution. In the range of temperatures of 55 to 60 °C, amylose dissolves and amylopectin passes into a colloidal viscous solution of starchy smear. Thanks to the action of the amylasa, the splitting of the α-1,4-glucosidic bonds occurs in the middle of the individual chains. That way, amylose is broken down into oligosaccharides with 6-7 glucoses and amylopectin into chains with 6-13 units of glucose. This rapidly decreases the viscosity of the solution, so-called runoff occurs. Stage three of the sugaring occurs due to the action of the amylasa. This of the grafts produced by the fluid chips away at the disaccharide maltose. If amylose have an even number of glucose units, they are split without the rest. If the number is odd, however, the cleavage ends with the formation of maltotriose molecules. (Basařová, 2010)

The splittingof amylopectin takes place similarly, but ends on the sections splitting to form a border dextrins. The binding of α-1,4 is then cleaved by the border dextrinase and ends with the emergence of the residues with 2 – 4 glucose. Border dextrinasa, but not on the application of a large chance, since it inactivates at a temperature of 65 °C. A similar problem in the form of the inactivation temperature of about 40 °C, even with maltase, which in the beginning at low temperatures breaks down maltose to two glucose, and in the case of sucrose, which cleaves sucrose to fructose and glucose, but its inactivation temperature is about 55 °C. (Basařová, 2010)

The theory of used methods

Chelatometric determination of water

Chelatometric determination is among the classic determinations of a measured analysis. The measuring solution of this determination is a solution known commercially as Chelaton III. It is effectively a solution of disodium salt ethylene diaminetetraocetic acid.

Detailed instructions for the chelatometric determination of water hardness can be easily found in laboratory exercises in analytical chemistry (Horáková, M. & kol. 2007), or on the website of the Department of Agri-environmental Chemistry and Plant Nutrition, for example.

Sugaring test

The sugar test detects whether the sugars in the sample are reducing or not. The difference between reducing and non-reducing sugar lies in the presence of a free aldehyde or ketone functional group present in a saccharide molecule. Practically for us, the difference lies in fermentability. Yeast can only process reducing sugars. So their presence is proven by iodine testing. Iodine in reaction with starch (as polysaccharide) shows an intense dark blue colouring. As the enzyme splitting of starch into simpler molecules progresses, the colouring changes to dark brown through brown to a bright yellow colour, which iodine reacts to in response with simpler sugars. The yellow colour therefore indicates the splitting of long chains of polysaccharide molecules into reducing sugars. (Kosař, 2000)

Instructions for primary school teachers

Sugaring test

This exercise is also well used to link biology with chemistry, thanks to enzyme fission, the breakdown of starch into simple sugars. So if the digestive system needs to be discussed, it is easy to point out. If multiple malt samples are available, each group can perform the sugar test with another, and in the end they can compare the colour and smell of the resulting malts.

Before setting begins, I recommend having pupils run a test on a piece of bread or bun, resulting in blue colouring proving the presence of polysaccharides and then on Glukopur.

This is the powdered glucose available in all pharmacies, resulting in a bright yellow colouring proving simple sugars. With this determination, pupils will then know what the final test result is supposed to look like.

Inclusion in the FEP (framework educational program):

CH-9-6-04 is familiar with the starting materials and products of photosynthesis and end products of biochemical processing, especially proteins, fats, carbohydrates

CH-9-6-06 will give examples of sources of proteins, fats, carbohydrates and vitamins (Rámcový vzdělávací program pro základní vzdělávání, 2017)

Equipment: dropper, porcelain white saucer or bowl, automatic water bath, mortar bowl with a pestle, glass rod, stand, cross-clamp, holder, thermometer, circle, filter funnel, filter paper, saucepan, scales, beaker, graduated cylinder.

Chemicals: Lugol’s solution (5 g iodine, 10 g potassium iodide, 85 ml of water)

Procedure of work: Take a piece of bread and a dropper to apply a Lugol solution.

Then on a white saucer, pour a small amount of Glukopur and again to flood the Lugol’s solution. Prior to the actual production of the wort it is necessary to first wanting to junk that malt. 50 grams of the sample of malt, gradually rub in a mortar.

Then stir the malt in 200 ml of water at 37 °C. After stirring the malt properly, start to heat to 45 °C on the water bath, keeping the solution at this temperature for 30 minutes. Then start slowly heating so that within 25 minutes the temperature rises to 70 °C. At this temperature, grumble for another 60 minutes. The solution should be mixed regularly. During the grubbing process, take a sweetener sample every ten minutes using a dropper, tip it onto a white saucer and add Lugol’s solution. Observe the colour change.

Work safety: protective equipment should be used when handling hot items, dry rag etc.

Teacher tips: If an automatic water bath with a controllable temperature is not available, the determination can be made in a normal water bath and the temperature monitored by a thermometer. If the pupils do not keep an eye on the temperature and inactivate the enzymes too soon, the sample will not sugar-coat them. In such a case, it is good to point out that the negative result of the experiment is also the result and draw the appropriate lessons. If Lugol's solution is not available, the iodine tincture available at the pharmacy can be used.

Examples of control questions:

Here's an example of polysaccharide:

Name the substances responsible for splitting starch:

What's the difference between polysaccharide and monosaccharide?

Instructions for grammar school teachers

Chelatometric determination of water

Chelatometry is a commonly used analytical method, offering relatively simple titrations for pupils with fairly visible colour transitions. Pupils can set their own samples of water delivered from home. They can also recall simple calculations when practicing practical skills. Determination is not particularly equipment intensive and the indicators used are not particularly expensive relative to other indicators.

Inclusion in the FEP:

Chemistry 5.3.2

Performs chemical calculations and applies them in solving practical problems.

Uses knowledge of the basics of qualitative and quantitative analysis to understand their practical significance in inorganic chemistry. (Rámcový vzdělávací program pro gymnázia, 2007)

Equipment: automatic burette, tap burette 25 ml and 10 ml, stand, cross clamps, holder, beakers, titration flasks, pipette 50 ml, 25 ml, 10 ml, 5ml, spoonful.

Chemicals: Ammonia buffer, Sodium hydroxide c = 1 mol/dm^3, Eriochrome T, Murexid, Chelaton III.

Determination of the total hardness of the water

Procedure of work: As per the amenity of the school can be to the titration to use the automatic burette, or the classic tap burette about volume 25 or 10 ml. If we use the 25 ml burette is appropriate pipet 50 ml of the sample. If a 10 ml burette, whether automatic or tap, is available, it is advisable to pipette 25 ml of the sample. So pip the required amount of water sample in the titration flask. Add 2 ml of the ammonia buffer for a sample volume of 25 ml or 4 ml of the ammonia buffer if you pipette 50 ml of the water sample. Maintaining a pH of around 10 is essential, the solution in the titration flask should clearly smell ammonia. Add the Eriochrome-black T indicator to the tip of the spoon. The solution turns violet. Then immediately titrate the 0,02 mol/dm^3 Chelaton III solution into the first significant colour change. Violet turns a blue color.

Calculation:

$$c_{(Ca^{2+}+Mg^{2+})} = \frac{c_{CHIII} * V_{SpCHIII} * 1000}{V_{vz}}$$

c_{CHIII} is the concentration of the standard solution Chelatonu III

$V_{SpCHIII}$ is the consumption of Chelatonu III in ml

V_{vz} is the content of the pipetted sample in ml

1000 is the conversion factor (conversion mol/ per mmol/l)

The determination of calcium ions

Procedure of work: As a result of the school's amenities, an automatic burette, or a classic tap burette of 25 or 10 ml, can be used for titration. If we use 25 ml of the burette, it is appropriate to pipette 50 ml of the sample. If a 10 ml burette, whether automatic or tap, is available, it is advisable to pipette 25 ml of the sample. So pip the required amount of water sample in the titration flask. Add 4 ml NaOH solution of c = 1 mol/dm^3 for a sample volume of 25 ml or 8 ml NaOH buffer if you pipette 50 ml water sample. Add the Murexid indicator to the tip of the spoon. The solution turns pink. Then immediately titrate the 0,02 mol/dm^3 Chelaton III solution into the first significant colour change. Pink turns purple.

Calculation:

For the calculation of the content of calcium ions was used the following formula:

$$c_{Ca^{2+}} = \frac{c_{CHIII} * V_{SpCHIII} * 1000}{V_{vz}}$$

Where:

c_{CHIII} is the concentration of the standard solution Chelatonu III

$V_{SpCHIII}$ is the consumption of Chelatonu III in ml

V_{vz} is the content of the pipetted sample in ml

1000 is the conversion factor (conversion mol/ per mmol/l)

Work safety: Work safety principles in the laboratory, i.e. not drinking, avoiding contact with eyes and skin, should be observed at work.

Teacher tips: Measured water hardness levels can be found on the relevant water management, so pupils can compare results. Murexide is spread with sodium chloride before use to dilute in a 1:100 ratio. It is appropriate for pupils to insert a white pad under the titration flask to make out the equivalence point better. If automatic apartments are available, it is important to warn pupils to fill them slowly and not to pressurise them. Otherwise, the Chelaton III spray is imminent.

Examples of control questions:

How do metalochrome indicators work?

Draw a titration apparatus: What units express the hardness of water?

Conclusion

Procedures for determining selected parameters of raw materials for beer production were selected and tested. It was proposed to include individual methods in teaching at primary schools and grammar schools to support the teaching of chemistry. The basic technological procedures have been modified for use in teaching chemistry.

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References

Kosař, K. (2000). *Technologie výroby sladu a piva*. Výzkumný ústav pivovarský a sladařský, Praha, Česko

Basařová, G. (2010). *Pivovarství: teorie a praxe výroby piva*. Vydavatelství VŠCHT, Praha, Česko

Basařová, G. (2015). *Sladařství: teorie a praxe výroby sladu*. Havlíček Brain Team Praha, Česko

Horáková, M. & kol. (2007). *Analytika vody*. Vydavatelství VŠCHT Praha, Česko

Team of authors. (2017). *Rámcový vzdělávací program pro základní vzdělávání*. MŠMT, Dostupné z: https://www.msmt.cz/file/43792/

Team of authors. (2007). *Rámcový vzdělávací program pro gymnázia*. Dostupné z: http://www.nuv.cz/file/159

CHALLENGES THAT FACES PHYSICS TEACHER IN POLISH PROGRAM AND IN PROGRAM OF INTERNATIONAL BACCALAUREATE

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Abstract

Present school, both private and public, at all levels of education, both in polish and in IB programme, caries different challenges that teacher has to face to. The whole spectrum of issues, like: need of both – education and bringing up young people, relations with students, parents, other teachers and head of school, influence of media and electronics, changes of expectations and methods of teaching and mentality, even in last over a dosen of years. And other aspects – need or aspirations of self development, professional promotion and many others, force teacher, both – young and this with long experience, to choose appropriate perspective and take a stand in process of teaching. Sharing among teachers with some answers of these questions could be worthy in process of development of education and bringing up of young generation. I would like to shortly discuss some of these issues in the context of person of physics teacher.

Keywords: Education, bringing up, physics, experience, challenges

There are many attitudes toward teaching, depending on a time and on a country, where lectures are given. So many new theories and pedagogical methods were presented. The following question may arise: is it possible to find relatively universal way of teaching, that would not be evolving all the time, changing like in a kaleidoscope with every gust of wind of new fashion in pedagogic? And also: is the human nature of learning unchanging? What proven methods can a physics teacher apply in his work? In this text I would like to shortly focus on a few aspects of that problem. Some literature given in references may be helpful (Woroniecki, 2013).

Undoubtedly a very good teacher, teacher *par excellence*, is a treasure. His character and knowledge can form students who one day may grow up to become worthy and reliable people. Fruits of his good work may be seen in next generations. Even if some of his ”children” (and „grand children” and further) will lose that potential, still at least some of them may pass it further and sometimes even develop it.

Moreover, once learned, character traits such as properly ordered need of self-development of both - teacher and student - as well as the will to sustain that need even after finishing studies/school, an appropriate motivation in that process (not only for money, carrier etc.), the experience and knowledge of some possible dangers (like exhaustion) and others, can be priceless and they can help to be better prepared for possible present and future threats in process of education, work and in everyday life.

Nowadays we face a problem of impoverishment of the teaching process. Many teachers do not look at the formation of the character of a student, and also commit other mistakes like eg.: neglecting the need of good philosophy (expecting only numerical results - at the university level it may be for example - doing calculations in quantum mechanics rejecting deeper view on the problem, also disregarding interpretations other than the Copenhagen one, not really even mentioning the other ones, also claiming that „quantum mechanics is so weird that even its fathers didn't understand it”) or not looking at some aspects of morality in science (eg. responsible applications of the inventions they made). Often it's not entirely their fault – it's the result of the teaching process of their „parents"-teachers (mentors). Also it wouldn't be correct if the teacher was only looking at character development and not giving needed knowledge. These two quotes of Servant of God, Fr Jacek Woroniecki OP, throw light on that matter of teaching:

"It is inappropriate when school take care only of the erudition, of furnishing the head with the set of practical informations omitting systematical development of spiritual authorities of a child; it is also bad when, spending a lot of work on that development, teacher neglects to arm student's mind with the informations that will inevitably need" (Woroniecki, 1925).

Few basic advantages of good tutor of young people are:

"First of all total self-control, including perseverance, patience and longthinking [*longanimitas*], and then: decisiveness, severity and high consequence, consistency in behavior, finally kindness to youth (...), this skill to lower oneself to their level, gentleness and indulgence towards their mistakes and politeness in external forms of behavior" (Woroniecki, 1924).

Our perception of bringing up children has changed dramatically since the '60 of 20th century, also in Poland. The idea of a rather strict and demanding teacher, children having high respect of their parents and teachers, strict rules and learning many things by heart (of course it is harder when students have websites like google, but it's still indispensable for every person) nowadays is often replaced by a new model of a teacher-student relationship, where they act almost as an older and younger partner. The same can be seen between parents and children - a lot of freedom (or rather lawlessness) is given to young people and so called „creative thinking" (but with lacks of knowledge) is being popularized. New media like TV, mobile phones and Internet amplify this process. Of course not everything was perfect 60 years ago, but general tendencies are pessimistic. Some things needed to be improved (like more respect towards students and more creativity, eg. in practical application of knowledge achieved or in making links between subjects, but of course without loosing the

„identity" of each subject). However presently we witness a totally opposite treatment of pedagogical or teaching rules. It leads finally to lowering level of: respect and obedience to the teacher, discipline, self-motivation to study and appropriate zeal in achieving goals. Level of education is also lowering constantly, which is amplified by the view that „it was too hard for students". Also anxiety about our children (who in fact are in the center of that situation) and yearning for more integrity in teaching style (visible for instance in growing popularity of home schooling) is clearly visible.

In that situation some people miss hard, even „prussian" methods of education. Some other propose to promote science as „fun". Other do not really care about all of that situation and just agree with prevailing circumstances and conditions. Is it hence possible to find any solution to this great problem? In my opinion maybe it would be worthy to come back to classical education and apply modern inventions to it (www.edukacja-klasyczna.pl). Teaching student using classical methods and rules of education, having all of advantages of the past would lead to optimal goal. A student, formed with classical rules, later, even without the presence of the teacher, will in many situations continue the process of formation by himself. Example of many generations taught in such a way confirm the advantages of that kind of education.

As it was mentioned, undoubtedly, lessons 50-60 years ago were different than nowadays. Also lessons of physics were different (Fizyka w szkole). Their shape and content are dependent not only on times but also on a country in which they were held. For instance in Poland the level of physics was very high. Many hard theoretical problems were solved, knowledge of mathematics was richer and even solutions presented in books were sometimes based on good independent knowledge of a student (famous: „after easy formulas transformations, we have..."). High number of lessons (lead also on Saturdays), some kind of mentality of struggle for success (not always with healthy attitude), popularity of olympiads and competitions, good books resulted in high knowledge of students. Poor students from these times could be really good presently. And not only in physics, also in other sciences.

That’s the truth.

Answering the question was everything perfect - of course not. Some things needed to be improved, eg. deepening abilities in conducting experiments or in general practical application of known theory in real life. Physics is not only solving problems, even very hard and with an unexpected final solution, but naturally also proposing, planning and doing experiments, achieving experimental results and making some conclusions and further confirmations and/or predictions (sometimes useful for next theoretical models). Theory and experiment should support each other.

Presently level of physics (but also of mathematics) is much lower. As was mentioned, many things were said „to be too hard”, number of lessons per week is not high enough and some new ideas like focusing excessively on an interdisciplinary approach with loosing a lot of basic content of subjects (making “mixture” of science subjects), devaluating individual nature of each of them (famous proposition from 2012 in Poland in case of subject ”science” – in polish „przyroda” - for high school students) - whereas reasonable interdisciplinary paths are very good - also with implementing topics far from real science (like “laugh and cry” in case of “przyroda” in 2012- sic!), may have negative impact on teaching physics.

Some motivating methods (like having trips to scientific laboratories or even to nuclear power plants, occasionally using simulations and watching movies or playing smart physics games) may be a good or even a very good idea but some of them (eg. weird pseudo drama – theatre plays) are just impoverishing formation and education of students. It would be relevant to teach prudent distance to Internet and electronics, treating them as a useful tool but being aware that it is influencing us (eg. our mentality, memorization, style of thinking and other elements of our character and behavior); we also need to be able - at least partially – to work without them (eg. doing simple calculations in mind or on paper).

Moreover having base from classical methods (using also *septem artes liberales*) we can deepen and widen, consolidate, knowledge given to students. Even facing changes of approach to education

(Euklides and his words: „Give to him three obols if he has to have profit from what he learns” vs „What is practical use and/or financial gain from this knowledge”), teacher enriched with classical education values, will be able to properly react to those changes. Of course no one expects physics teacher teaching only about philosophy and theory of science, having „romantic-style” students, it is clear. But with proper focus on each aspect, we can form young person integrally.

Once again the conclusion could be made that using classical methods of formation of students, using also well proven working methods with application of modern technology (*inter alia* using support of computer and other electronic equipment in conducting experiments), solving both rather hard theoretical problems and doing experiments, seems to be proper way of teaching physics.

In International Baccalaureate program teacher of physics may sometimes face different challenges than in Polish one. One of them can be obligation to do and to describe a given number of experiments by each student. Teacher has to mark them according to official regulations. Also types of theoretical problems and scope of material is different. Even number of exam papers (more than one and possibility to write extended essay may be surprising. Some of propositions given by IB are really interesting (especially emphasis on the need of doing and describing the results of experiments, but also a chance to choose topics relatively unusual for high school students, eg. from electronics). Some aspects, in my opinion, could be better, eg. proposing harder (deeper) theoretical questions.

The IB program started in 1968 (www.ibo.org). As we can read from its official page, trends in the ‘60 (referred to as “traditional”) were: memorisation, same content for all, hermetic subjects, IQ tests, didactic, teacher-centred, academic intelligence, norm-referenced, machine-scored tests, translation (languages), closed classrooms and national perspective whereas nowadays there are new trends (labeled as “progressive”). These are: critical analysis, student choice, interdisciplinarity, range of skills testing, constructivism, child-centered, education of the whole child, criterion-referenced, AV and AL (languages), open plan rooms and multiple perspectives.

In my opinion each point could be widely discussed and could be (partially) understood differently by different teachers. We also need to look at good will of each teacher. Some elements of these „modern" trends could be adapted to the „old" ones (even in tiny, but important aspects, like translating some words into English - then physical symbols and equations may become more understandable). But this comparison also gives many informations about the intentions (at least some of them) of its authors.

In general, the idea of international maturity exam is very worthy of attention. But the question how exactly should it look like may arise. We could also ask another question about IB program: is education provided by IB conceived as an international program for everyone or rather as an international program for those who aspire to become an elite? Also we could ask similar question about Polish program of education, for instance about maturity exam (in polish - „matura"), particularly maturity exam in physics - what do we expect from it and after this exam from young people? What kind of young generation we would like to educate? How we and other teachers, schools, can teach young people - as a group and individually - not forcing every one of them to have the same level of knowledge and the same diplomas but to educate and develop specific gifts of our students? What possibilities of education (high schools, technical schools etc.) can we offer? We know that even students not gifted in physics, may develop some interest in that subject and, even having completely different job in the future,, they can use elements of knowledge and passion we gave them. These and other important questions have to be asked by every teacher by himself, in Polish and in other programs, realizing what a great responsibility we have.

Continuing these considerations, in the last few decades important reforms of education were conducted in Poland. We can take as an example a reform from 1999 prepared by then Minister of Education - Mirosław Handke, which among other things, introduced 3 years of middle years (junior high school, in Polish – „gimnazjum"), changing Polish educational program from 8+4 years into: 6+3+3 years. In year 2017 another Minister of Education - Anna Zalewska, returned to previous educational schedule. The argument was that 20 years of existence of “gimnazjum” had negative influence on polish youth. Author of this text, was both a gimnazjum student (almost at the beginning of its existence) and a gimnazjum teacher (in its last years) and can confirm the validity of complaints of many teachers, parents and students, such as: rise of aggressive behavior of 13-16 years old students, lowered level of education, finally also a simplification of maturity exam at the end of high school and other problems. One anecdote said by a university professor around year 2010 shows the trends: around year 1990, at first lectures, when he asked a question - „who knows differential and integral calculus?” - around 2 - 3 students didn’t rise their hand; around year 2010 – when he asked the same question, around 2-3 students rose their hand. Author of this text was surprised a few years ago, when he realized that there were 13-14 years old students who didn’t know the Pi number. There could be many more of such stories. If we also realize that maturity exam is condition *sine qua non* to enter university, the general view could become very pessimistic. But fortunately there are still many positive or even very positive situations. We can meet ambitious and hard working teachers and students, many Polish students are willing to take part in competitions, results obtained by Poles eg. in International Physics Olympiad are good. Also level of teaching physics at Polish universities is good.

Obviously it’s good to lay claim to have high or sometimes even very high level of education (at any stage); for instance some elements of Japanese style of teaching could be commendable, but of course, as everywhere, some exaggerations may happen (eg. in mentioned Japanese schools) - the case of Lew Landau’s „physical minimum” exam, which past 43 students during 27 years of its existence, can be an example.

It’s worth to add, that some elements of history of science, also history of physics could be very valuable. It is not only a fascinating part of education, but it may be an enriching experience (even for a teacher!). For sure one of the strong points of IB program is obligatory subject - TOK (theory of knowledge), where students learn many things related to mentioned theory. Links between TOK and physics are clearly visible, eg. in such topics, like: methodology of science, logic of scientific discovery etc. This shows the need and expectations of elements of philosophy and theory of knowledge in science.

Also very important are possibilities that a physics teacher has. We can include here for example: how rich is physical equipment that we have, how much support we have from school headmaster (in organization of competitions, financial support to organize trips etc.), how motivated our students are (partially it depends on us, but not entirely, eg. what was the previous physics teacher etc.) and how much we can encourage them to promote physics at school (but also outside school), for example in making posters and presentations; how much time we have for extra lessons with interested and gifted students (in some schools there is absolutely no time, whereas in others it is almost natural to have such extra classes).

Furnishings of our small laboratory is very major point of our lessons. Of course, nowadays we rather can not find 1-litre jar of mercury (quite possible 40 years ago), just as we couldn't use a new computer back then. School equipment is changing partially over time and also may depend on country (eg. in USA it is possible to legally own small samples of uranium whereas in Poland it is strongly forbidden). Also the fact how frugal, but longthinking is the teacher, translates into specific set of tools of school laboratory (eg. in case of having the same amount of money – how will it be spent by a given physics teacher). Smart attitude in different aspects of that situation may be fundamental. Of course some equipment is necessary, often in relatively poor laboratories we can find something really useful, some tools we (or the students) can make by ourselves, also some – even expensive – tools are worth to be bought, especially if we know that we can use them for many years. What is more, sometimes even having no equipment, we can conduct good lessons (the example from the past can be of some Polish school before '89, where students having no computers, were „programming"... on paper, later having very high results on real computers). Undoubtedly, good equipment is important, but even having some deficiencies in it, a good teacher can conduct valuable lesson.

What's important, our lessons of physics do not have to be boring, only solving hundreds of theoretical problems, nor need they to be filled all the time with „fireworks", trying to amaze people. They can be normal and absorbing at the same time, widening and deepening physical knowledge of our students.

Lessons of physics can also depend on priorities set by school, students or a system proposed. For example in some of noble Polish schools (these are the best in nationwide ranking) the goal may be to get high result in olympiad which may result in students being released from writing maturity exam and having free entrance at very good university, whereas in schools with IB program it may be to obtain high results in given subjects (and in all IB program) to have a high number of points allowing students also to apply to very good, often foreign, universities.

Physics is very beautiful, but also a very hard area of science. It is worthy to teach it according to good approaches, but teacher has to remember that during the process of implementation of his methods, of course he needs to look at possible impacts and obstacles, like: lack of time, troublemaker students, issue of teaching in a public (high influence of the government and ideas of region/given country) or in a private school (high influence of parents, money), just different expectations of parents (very influential, especially in private schools), comparing his methods to methods of other teachers etc., mentioned influence of media and new technologies (also a problem of possible recording of lessons and sharing them on the Internet), but showing sincere and clear view of the situation he can achieve at least some of these goals.

As mentioned before, behavior like: appropriate distance between teacher and students but with kind relations between them, having high but not very strict expectations towards young people, presenting high demands for all students but with some reasonable exceptions if they are needed, also looking individually at each student – even such reasonable point of view can seem to many modern parents as old fashioned. The countercultural movement of ‘60 of 20th century brings its fruits. Many parents and teachers are unsatisfied with so called stress-free upbringing (or permissive parenting). But the point is not only to complain – directly or indirectly – about that situation, but to take action in this area. And this action has to be taken not only in formation of behavior but also regarding the appropriate level of teaching physics (or in general other subjects).

And of course not everyone will be satisfied with that; The school environment will also be very important. But conducting our lessons well, having good results (in tests, in competitions and comparing them to students taught by present - modern – methods), after some period of time, step by step, we can convince that this could be a proper way. Even in poor schools, like schools located in dangerous, neglected areas it is possible to have some success. I know from experience of other teachers and mine, that even neglected students can show impressive results if we devote to them some understanding, patience and knowledge; then even our high demands may be positively adopted by them. In that and in other cases, being patient with ourselves and with students is important. Process of development takes time but it may bring very fruitful results.

In this short text I wanted to discuss just a few aspects of this topic. The problem is much wider and deeper and it would need much longer analysis. Literature given in references may be helpful for further considerations.

References

Woroniecki J., OP. 2013, „Katolicka etyka wychowawcza” („The Catholic Educational Ethics”) 3 vols., Fundacja Servire Veritati. Instytut Edukacji Narodowej, Lublin

Woroniecki J., OP. 1925, „Około kultu mowy ojczystej” („About the respect of motherland language”), p. 15, Lwów - Warszawa

Woroniecki J., OP. 1924, „Zdolność wychowawcza szkoły publicznej i jej granice” („Educational ability of school and its boundaries”)

(Miesięcznik Katechetyczny i Wychowawczy 13), p.76
Website about classical education: www.edukacja-klasyczna.pl
Magazine „Fizyka w szkole” („Physics at school”) - different issues
International Baccalaureate Programme. www.ibo.org

UPPER SECONDARY SCHOOL TEACHERS AND PUPILS AT THE FACULTY OF SCIENCE, CHARLES UNIVERSITY – THE AUTUMN SCHOOL OF CHEMISTRY

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Abstract

Since 2015, the Chemistry Section of the Faculty of Science of Charles University has been organizing a seminar for upper secondary school Chemistry teachers from all over the Czech Republic as well as their pupils studying their upper secondary school pupils (year 3/4; 17 – 19 years old) with an interest in chemical disciplines. The seminar is organised during the two-day autumn holidays, at the end of October, in the building of the Chemistry Section of the Faculty of Science, Charles University. The aim of the seminar is to present the ongoing research at each Department of Chemistry. At the beginning of the seminar, the heads of departments introduce each of their scientific teams of their departments as well as the topics of their research. Afterwards, all 4 blocks of lectures (3 for teachers and 1 for pupils) and 4 laboratory sessions (1 for teachers and 3 for pupils) are provided by representatives of each Chemistry Department. The program also introduces the Library of the Chemistry Section of PrF UK, a necessary part of studying at the university. At the end of the first day, there is an evening theatre performance with a chemical theme performed by the members and pupils of the Department of Teaching and Didactics of Chemistry. To this date, the seminar has already been organised five times and therefore it can already be evaluated. Over the five years, the seminar has already managed to have its spot in many of participants' calendars. Moreover, teachers attending this event regularly bring also new pupils every year to motivate them to study at the Chemistry Section of Faculty of Science, Charles University.

Keywords: chemistry education, autumn school of chemistry, seminar for chemistry teachers

Introduction

One of the aims of the seminars organized by the Chemistry Section of the Faculty of Science of Charles University is to provide information about current research in chemistry performed by individual teams of the Chemistry Section of Faculty of Science to upper secondary school teachers. Another goal of the seminar is to invite upper secondary school pupils, mainly those completing their last year (eventually last two years) of upper secondary school education, to visit the interiors of our university – classrooms as well as laboratories of each department. This tour introduces the pupils the premises where they could study one day.

Participants of our seminar

The seminar of the Chemistry Section of the Faculty of Science of Charles University for upper secondary school teachers and pupils is called The Journey to Studying Advanced Chemistry. The participants of the seminar can register using Google docs – a link to this document is annually sent to more than 600 e-mail addresses belonging to teachers or upper secondary school secretariats across the Czech Republic. Each teacher can register up to 2 of their pupils. Similar system of colleting feedback from teachers (via Google docs) is used once the seminar finishes. Since 2015, the seminar has been held during the autumn break – two days at the end of October. This time arrangement has proven to be suitable for teachers as well as their pupils (figures 1 – 5) as some of the teachers attended the seminar more than once. Furthermore, some of upper secondary school pupils also attend this seminar twice during their final two years of upper secondary education.

Due to the capacity reasons, the number of participants had to be restricted to 100 participants (50 teachers, 50 pupils) the first year. Owing to the high number of participants, the capacity of the seminar was increased by 50 % to 75 teachers and 75 pupils for the next years. Some of the teachers attended the seminar without their pupils and vice versa. The number of participants in each year is shown in tab. 1 - 4.

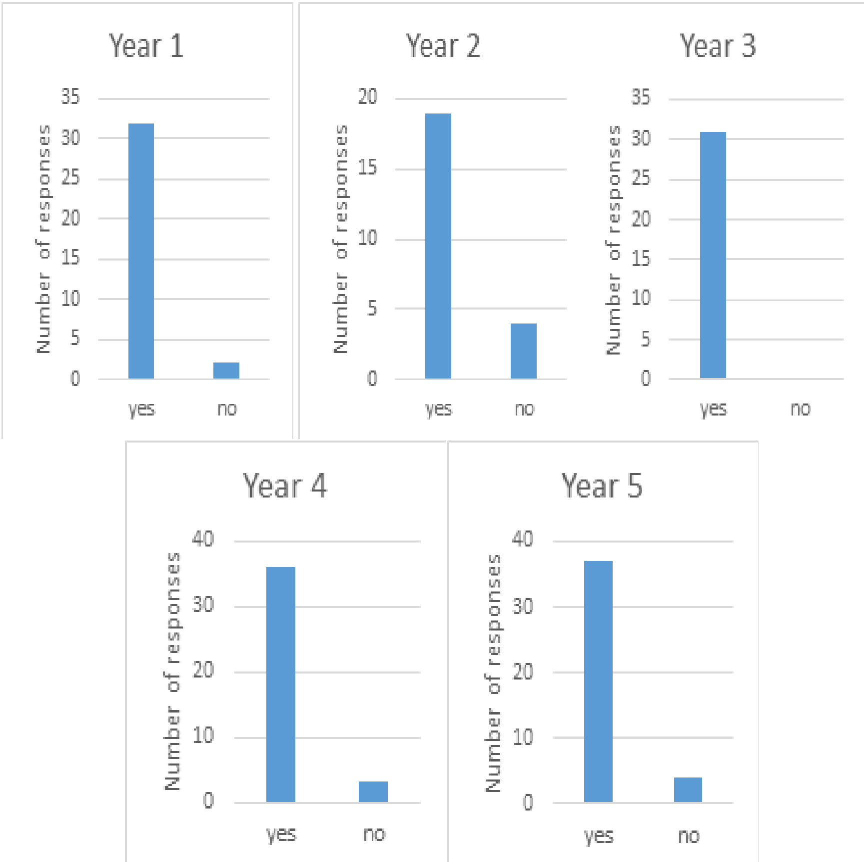

Fig. 1 – 5. Feedback from teachers: „Is the date of the seminar suitable for you?“

Tab. 1. Repeated seminar participation of teachers throughout years

Number of attended seminars	1	2	3	4	5
Number of teachers	66	24	15	11	10

Tab. 2. Teachers attending the seminar once only

Year	1	2	3	4	5
Number of teachers	18	12	12	5	19

Tab. 3. The number of registered/participating teachers in each year

Year	1	2	3	4	5
Number of registered teachers	49	54	50	51	61
Number of participating teachers	46	52	49	48	58

Tab. 4. The number of registered/participating pupils in each year

Year	1	2	3	4	5
Number of registered pupils	55	75	80	78	78
Number of participating pupils	50	72	77	76	69

Program of our seminar

The program of the seminar is divided into two days and all six Departments of Chemistry put equal effort into the event. Each of them provides lectures and laboratory sessions for teachers. Since the second year of our seminar, laboratory sessions for teachers are considered to be an integral part of their program as teachers requested it in the poll during the first year of the seminar (graph 6). The program of the seminar can be divided into three parts: program for teachers, program for pupils and program for teachers as well as pupils. The summary of the program is shown in table 5.

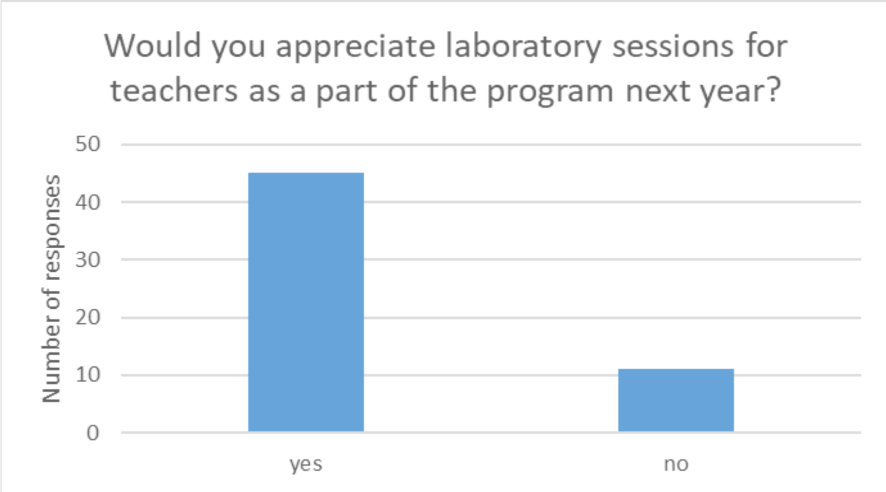

Fig. 6. Year 1 - The result of a poll considering laboratory sessions as a part of the seminar the following year

Tab. 5. The program of the seminar – time plan

	Day 1
9:30 – 10:30	*Registration of participants, refreshment*
10:30 -10:35	Opening - introductory word of the Vice Dean of the Chemical Section
10:35 – 11:35	Introduction of departments - introductory words of the Heads of Departments
11:30 – 12:30	*Lunch*
12:30 – 14:45	Laboratory session for pupils
12:30 – 14:45	Lectures for teachers
14:45 – 15:15	Refreshment
15:15 – 17:30	Laboratory session for pupils
15:15 – 17:30	Lectures for teachers
17:30	*Social evening - a theatre performance and dinner*

	Day 2
8:00 – 8:30	Refreshment
8:30 – 9:00	Opening - the word of the Vice Dean for Student Affairs
9:00 – 12:00	Laboratory sessions for teachers
9:00 – 12:00	Lectures for pupils
12:00 – 13:00	*Lunch*
13:00 – 14:00	Presentation of the Library of the Chemistry Section
14:00 – 14:30	Refreshment, handing over the certificate
14:30 – 17:00	Laboratory sessions for pupils
14:30 – 17:00	Lectures for teachers
17:00	Closing of the conference

Program for teachers as well as pupils

Teachers and their pupils attend some parts of the program together. First day in the morning, all of them are welcomed by the Vice Dean for Chemistry Department. Their program continues with a sequence of introductory words of the Heads of each Chemistry Department to inform the pupils and teachers about the ongoing research of their team. The introductory part lasts an hour and the program of the day continues according to the table 5.

The second day begins with the introductory speech of the Vice Dean for Students Affairs during which the potential future students are provided with information about study programs, conditions and important dates for admission and further information regarding first steps in the specific study programs. The last part of the program for both groups – pupils and teachers – is the visit of the Library of the Chemistry Section.

Program for teachers

There are three series of lectures focusing on ongoing research of individual Departments of Chemistry (pic. 2). Teachers can also take part in laboratory sessions based on their preferences as each of them chooses 3 out of 6 laboratory sessions. The three most desired laboratory sessions are incorporated into the program of the seminar.

Pic. 1. Evening performance.

Pic. 2. Teachers at a seminar.

Program for pupils

There are three laboratory sessions for each pupil in our two-day program (pic. 3). Pupils are divided into three groups. Laboratory sessions incorporated into pupils' programs are chosen so that each Department of Chemistry organises at least one such event. There are 9 laboratory sessions for pupils in total and the program for individual pupils is created according to their preferences filled in their registration form. Additionally, all pupils attend a series of lectures held the second morning of the seminar (pic. 4).

Pic. 3. Pupils in the Analytical Chemistry lab. Pic. 4. Pupils attending a lecture.

There is a social evening at the end of the first day of the seminar (pic. 1). The evening starts with an original theatre performance the topic of which is chemistry. After this show, all participants including organizers, lecturers and lectors of laboratory sessions are invited for a dinner. This arrangement allows teachers and pupils to discuss their field of interest with lecturers and lectors further.

At the end of the seminar, all participants receive a certificate confirming their participation in the program. The seminar is accredited by the Ministry of Education as program providing continuing teacher education. Certifications for pupils are provided by the Section of Chemistry.

Feedback from teachers

Within a week from the end of the seminar, all teachers are asked to fill in a questionnaire the aim of which is to receive teachers' and pupils' evaluation of individual parts of program of the conference (graphs 7 – 9). Each lecturer and lector of laboratory session taking part in the program is individually evaluated and receives his/her evaluation. The questionnaire is created in Google docs. It contains 21 questions (the questions vary depending on the number of lectures). The system of evaluation is similar to school evaluation – teachers choose a mark on a scale 1 to 5 and also they can add a comment.

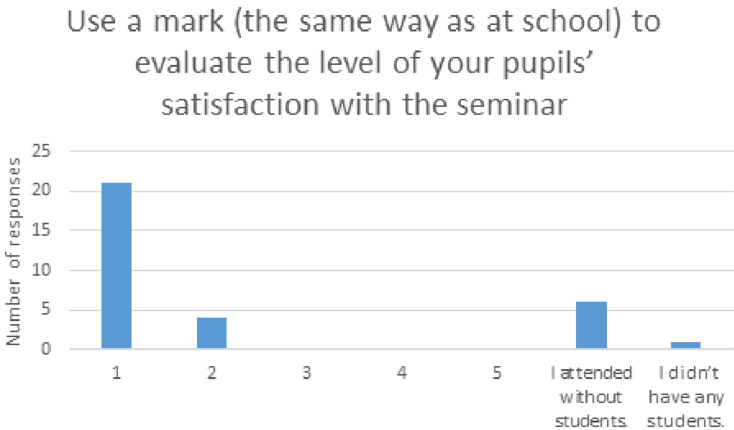

Fig. 7. The illustration of pupils' satisfaction with their two-day program – Year 4

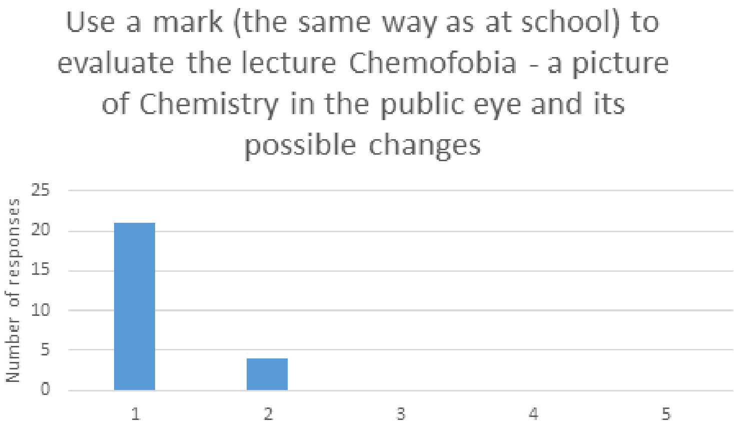

Fig. 8. An illustration of a well-evaluated lecture (by teachers)

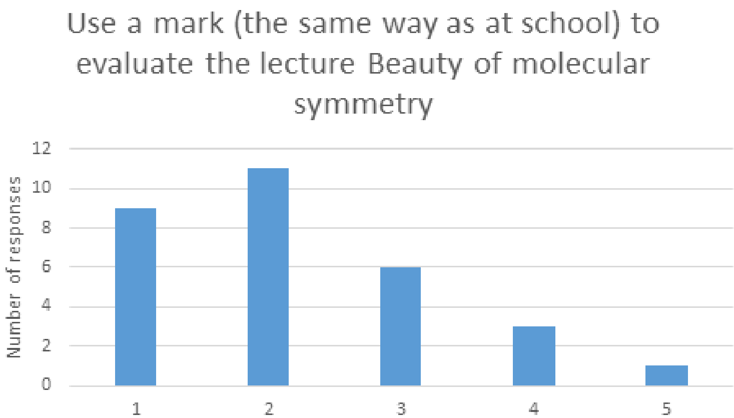

Fig. 9. Another illustration of an evaluation of a lecture

- The topic is interesting, but too difficult for those who didn't study mathematics at university.
- This lecture was very academic without a chance of using its content in practical tasks.

Changes in the concept of our seminar in each year

The first year of seminar gave us invaluable experience for organizing the following years. The program of the first day begins with an introductory words of Vice Deans for the Section of Chemistry whereas the second day with an informative lecture of Vice Dean for Student Affairs. There are also traditional parts of the seminar held since the first year – the introduction of each Department of Chemistry, a theatre performance and a social dinner at the end of the program the first day.

During the first year, the program of the seminar was divided into 6 sections each lasting 2 hours (3 sections per day) – each section dedicated to one Chemistry Department. Each of these sections consisted of three parts – an introduction of the department for teacher and pupils, laboratory sessions for pupils and two lectures for teachers. Since the second year of the seminar, the introduction of the library of the Chemistry Section and its services has become a part of the conference. The lecture focusing on library and its service lasted two hours, but it was shortened to one hour since the fifth year of the conference.

Discussion

In 2015, the first year of new seminar was organised for Chemistry teachers and their pupils (mostly studying their last year of upper secondary school). Teachers were contacted via their e-mail addresses or the secretariat of their school. Nowadays, invitations as well as registration forms are sent to more than 600 e-mail addresses every year.

The capacity of the first year was restricted to 50 teachers and 50 pupils as the premises, lectures and laboratory sessions were arranged for limited number of participants. In the first year, the seminar was attended by 46 teachers and 50 pupils (tables 3 a 4). Since the capacity of the seminar almost reached its limit (96 %), it was increased to 75 teachers and 75 pupils for the following years (up to 80 teachers and 80 pupils can be registered as we expect the actual number of participants to decrease slightly due to illness, personal reasons, …etc.). The number of participants are shown in tab. 3 and 4 – the capacity of the seminar almost reaches its maximum despite its increase after the first seminar. The seminar is very popular among pupils – unfortunately, the capacity of laboratory sessions cannot be further extended. On the other hand, the data show that the number of teachers has not reached the maximal capacity of the seminar.

Each year, teachers are asked to fill in a questionnaire evaluating the program of the conference so that it can be further improved and adjusted to their needs. We received feedback from between 65 % and 83 % teachers each year with the exception of the first year. Although only 46 teachers attended the conference, 58 questionnaires were filled in after the seminar. We suppose that some of the teachers probably sent the questionnaire to their pupils to complete it as well.

To sum up, there were major changes in the structure of the program of the seminar after the first year based on proposals from lectors of laboratory sessions who requested a time extension for their laboratory sessions. Since the second year, pupils attend "only" three extended laboratory sessions. There have not been any further changes in the structure of the program since the second year.

Conclusion

The fact that many of the teachers attend the seminar regularly is considered to be a success. Each year, we appreciate teachers bringing new pupils – potential future students of Chemistry Department, Faculty of Science, Charles University – to take part in our seminar.

Acknowledgement

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References

Hybelbauerová, S., Čtrnáctová, H. Cesta do hlubin studia chemie - seminář pro SŠ pedagogy a jejich žáky. In: Prokša, M., Drozdíková, A. Inovácie a trendy v prirodovednom vzdelavani. 1 vyd. Bratislava: Katedra didaktiky prírodných vied, psychológie a pedagogiky, 2016, s. 68-73.1. ISBN 978-80-223-4175-2.

SUPPORTING ECOSYSTEM SERVICES IN THE CITY – EXTENSIVELY MANAGED LAWNS IN KRAKOW

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Abstract

The green areas of cities include mainly forests, parks and squares. However in recent years the literature on sustainable lifestyles, health and recreation has increasingly focused on the roles and functions of urban green spaces such as lawns. They have important aesthetic and health values and also provide a number of ecosystem services. It is now appreciated that green areas in cities make urban areas more attractive for tourists and visitors. Cities are places for work, recreation and relaxation. High quality green areas contribute to a more stable microclimate, increase water retention, decrease heat, and mitigate extremely cold temperatures during the winter. They are a mechanical barrier protecting against pollution, noise and artificial light. They also have an educational function. The aim of this article is to show the benefits of ecosystem services provided by unmown lawns and flower meadows in the city, based on the management of green areas in Krakow.

Keywords: urban ecosystems, biodiversity, sustainable cities, human welfare

Introduction

Green areas in the city of Krakow as cultural and historical heritage

Touristic promotion of Krakow is mainly based on architectural and historical attractions, however Krakow has many valuable green areas that are worth visiting and are part of the history of the city. The aim of this article is to present some of the green attractions of Krakow and put new light on lawn management in the city, including its advantages and disadvantages.

Among the most remarkable green areas in Krakow is Błonia – a park in the form of a large meadow (formerly a communal pasture) with an area of 48 ha, near the historical city center. Błonia is one of Europe's largest meadows located in the strict city center. The history of the park began in the year 1162. The meadow was first used by peasants from neighboring villages to graze their cattle. Until the 19th century, Błonia was often flooded by the nearby Rudawa river in the spring turning it into wetland. After draining the area, Błonia became suitable for hosting large gatherings. Today Błonia is a recreation area, frequently hosting cultural events such as concerts, festivals and exhibitions. The site regularly hosts the Iuvenalia student festival, concerts or religious ceremonies, e.g. mass celebrated by the Pope during his journey to Poland (https://en.wikipedia.org/wiki/B%C5%82onia).

The best known park in Krakow is the Planty Park, established between 1822 and 1830 in place of medieval city walls forming a green belt around the Old Town. The park has an area of 21 hectares and length of 4 kilometers, forming a walkway popular with tourists and citizens. It consists of public parks and gardens designed in various styles and filled with trees, flowers and historical monuments (https://www.inyourpocket.com/krakow/planty_60717v).

The Planty Park is known as the "lungs of the city", as old trees that grow here play many functions – starting from forming a local microclimate with higher humidity and shade to an aesthetic role. One of the functions of trees in the city is to trap pollutants and toxic compounds from the air. In places with heavily polluted air, trees can remove up to four times more pollutants than in places with cleaner air (Szczepanowska, 2007). The main source of pollutants in the air are the exhaust gases produced by cars. They include sulfur, nitrogen oxides and heavy metals, among others. Roadside green areas are a natural barrier that isolate from road surface pollution and worn tires (Woźny, 2015). Plant barriers, in addition to the accumulation of pollutants, limit noise. In an increasingly urbanized environment, noise causes many health problems and is a nuisance for people. Proper planting of vegetation reduces the noise level. Plants disperse and then absorb part of the acoustic waves, reducing their intensity (Sobczyńska, 2014).

Within the city borders, there are also nature reserves and areas protected within the Natura 2000 Network. One of these is the Dębnicko-Tyniecki Meadow Area, located in the south-western part of Krakow. It preserves species-rich wet meadows and fragments of xerothermic grasslands, covering 282,9 ha. The Dębnicko-Tyniecki Meadow Area is a habitat for many species of birds and butterflies. The area primarily protects the metapopulations of two *Maculinea* butterfly species: *M. teleius* and *M. nausithous* (Zawartka, 2013).

Although Krakow has more than 40 city parks and 5 reserves within the city borders, this represents only 10% of the area of the city, a small fraction given the positive impact of a good quality environment on climate, environment and human health. Krakow's population is estimated at 768,730 people. The city borders encompass 18 km north-south and 31 km east-west. According the World Health Organization, in 2016 Krakow was classified as the eleventh most polluted city in the European Union. The geographical location of the city, in a basin close to the Vistula River, limits natural ventilation. On three sides, it is surrounded by hills that limit the movement of air masses. About 30% of days per year are windless, for another 30-40% of the time the wind does not exceed 2m/s. This results in high smog levels, especially during the heating season in autumn and winter. The air in Krakow is polluted mainly with fine particles of dust and toxic benzo(a)pyrene. In addition to the obvious health consequences, the effect of dust pollution is a noticeable reduction in air transparency in the city. The sources of pollution are mainly solid fuel furnaces (34%) and dust inflow from outside of the city (36%), but also local industry (17%) and traffic (13%). Heating furnaces are also responsible for 68% of the emission of the carcinogenic benzo(a) pyrene, which, according to calculations of the NGO Krakow Smog Alarm, the amount inhaled by Cracovians during the year is the same as in the case of smoking about 2500 cigarettes.

Other cities in Poland do not produce significantly less pollution and yet have noticeably better air quality. This is because of their location. Examples include Warsaw or Wroclaw, which are also located in river valleys, but the terrain is flat, facilitating the movement of air. Other large Polish cities are located at the seaside, such as Gdansk, where the natural northerly winds disperse smog. Due to its unfavorable location, Krakow should place even more emphasis on improvements to air quality and surfaces of good quality green spaces in the city.

The concept of ecosystem services and its importance

The ecosystem services concept helps to place a value on the environment and includes socio-economic and conservation objectives. Ecosystem services are described as all benefits that humankind obtains from ecosystems and are arranged into four categories:

Provisioning services –include services such as primary production, soil formation, habitat provision and pollination. These services make it possible for the ecosystems to continue providing services such as food supply, flood regulation and water purification (https://www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Ecosystem-Services).

Regulating services –include many natural processes such as carbon sequestration and climate regulation, waste decomposition, water and air purification, pest and disease control, flood protection (https://www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Ecosystem-Services).

Cultural services –comprise the use of nature for therapeutic purposes (animal assisted therapy) (Kapustka and Budzyńska, 2020), scientific discovery and education roles such as the use of natural systems for educational excursions. Cultural services also include recreational experiences like ecotourism, outdoor sports and recreation and inspiration for artists in paintings, folklore, writing or creating national symbols (https://www.millenniumassessment.org/documents/document.286.aspx.pdf).

Supporting services –encompass benefits that allow for the other ecosystem services to be present. They include nutrient cycling and primary production. The movement of nutrients through an ecosystem by biotic and abiotic processes is part of the life cycle of organisms as they die and decompose, releasing the nutrients into the neighboring environment. The service of nutrient cycling eventually impacts all other ecosystem services as all living things require a constant supply of nutrients to survive (https://ncert.nic.in/textbook/pdf/lebo114.pdf). Primary production refers to the production of organic matter, i.e., chemically bound energy, through processes such as photosynthesis and chemosynthesis. The organic matter produced by primary producers forms the basis of all food webs. Further, it generates oxygen, a molecule necessary to sustain animals and humans (https://ncert.nic.in/textbook/pdf/lebo114.pdf).

Well-functioning ecosystem services have the ability to self-regulate and operate efficiently. They supply the resources needed to maintain all processes on our planet and maintain a sufficiently high diversity of habitats and species, which in turn ensures the stability of resources for life on Earth, including human well-being. It is worth emphasizing that the implementation of good practices in protection of ecosystem services in cities is of great importance. It shapes a positive social attitude to greenery in public spaces on a large-scale, giving the opportunity to interact with a relatively biodiverse natural environment.

The aim of the study:

The aim of the study is to increase awareness, promote and support good practices in protection of ecosystem services in the city using lawn management as an example. In recent years, the aesthetics of urban greenery have changed from evenly cut lawns to extensively used meadows. Changing the management of green areas in the city from intensive to extensive supports a number of ecosystem services that are particularly necessary in highly fragmented urban ecosystems.

Methods

The study was performed in 2019 and 2020 in Krakow. In 2019 intensively mowed lawns, extensively managed lawns and flower meadows were visited once a month from June to August to observe and describe ecosystem services that they support and document threats to these three types of lawn use. In 2020 a short pilot experiment was performed to check how an unmown lawn affects ground temperature compared to a mown lawn. Measurements using i-*Buttons*™ (Maxim Integrated *Logger) were taken over two consecutive days in May 2020. The loggers were placed on the ground in the boxes ensuring shade. Measurement of temperature (°C) was carried out every ten minutes.*

Results

Ecosystem services supported by extensively mown lawns and flower meadows

Extensively used lawns are lawns mown 2-3 times a season. As a result, native plant species such as various grass species, flowering plants and herbs produce flowers and seeds. Due to extensive mowing, the lawn takes on the features of a meadow, with dense vegetation containing several dozen plant species. Plants produce seeds and sow the area to expand again in the following year.

Flower meadows are meadows sown from purchased commercially produced seed mixtures. They are multi-species mixtures, consisting of native and foreign species. They require extensive mowing (2 times a season). Often the starting point for the formation of a seed mixture for a flower meadow is the color effect and flowering time of individual species in the mixture. Flower meadows usually require sowing in the following years, which increases maintenance costs.

These two types of lawn management in the city help to store water. Dense plant cover limits water evaporation from the soil surface and root systems (even 25 times longer roots than in intensively mown lawns), retaining water in the soil. Therefore the water demand of extensively used lawns and flower meadows is much smaller, limiting watering and thus saving resources. The extensively managed lawns and flower meadows also absorb twice as much water as lawns, providing protection against flooding and mitigating against drought. Extensive management of lawns and flower meadows significantly decreases the costs of mowing and watering and protects against noise and pollution. Over a period of one hour, an operating mower emits 90dB of noise and a large amount of dangerous fumes. In one season intensively "cared for" lawns require about 20 mowing events, while extensively managed lawn or flower meadow are mown only twice. Moreover, extensive management means the plants does not need chemicals or fertilizers. Extensive management is less expensive and much more environmentally friendly. Higher vegetation helps to fight smog and cools the air (Mann-Whitney U test, $N_{mown} = N_{not\ mown} = 214$; $U = 18856$; $Z = 3.16$; $P < 0.005$ Fig. 3). Plants growing in extensively managed lawns and flower meadows are even 10 times taller than on short-cut lawns, so they better catch smog and mitigate against extreme air temperatures. Both flower meadows and extensively managed lawns are food sources for wild pollinators and other animals (insects, birds, small mammals). Unlike grasses, flowering plants provide pollinators with nutritious pollen and nectar. Dense vegetation gives shelter and space to live and reproduce for many species.

Disadvantages connected with flower meadows include higher costs and dependence on purchased seed mixtures and risk of introducing alien invasive plant species. A disadvantage of extensively mown lawns may be natural meadow-like visual aesthetics, in which there are few species with spectacularly colored flowers. Most importantly, extensively managed lawns ensure the durability of a significant number of ecosystem services in the city based on native plant species. A visual comparison of intensively mown lawns, extensively managed lawns and flower meadows is presented in Figures 1a, b and 2a, b.

Fig. 1a. *An unmown lawn with high vegetation and blooming flowers in a vegetated strip between motorways – this kind of extensive management protects natural processes and supports ecosystem services in the city.* **1b.** *A mown lawn along a street – an example of intensive management (photo: E. Rożej-Pabijan, 24th August 2019, Krakow)*

Fig. 2a. *A city park in Krakow with two types of greenery management – in the foreground a drying, mown lawn, in the background a blooming flower meadow.* **2b**. *Extensively managed flower meadows are fully flowering even in late summer and provide a range of ecosystem services (photo: E. Rożej-Pabijan, 26th August 2019, Krakow)*

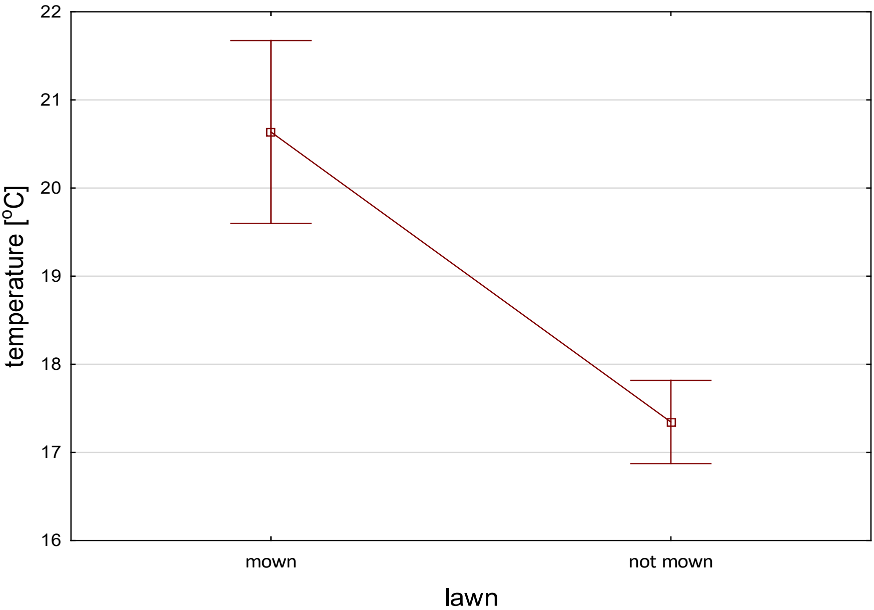

Fig. 3. *Mean temperature on two pilot experimental (mown vs. unmown) lawns in Kraków (performed by Joanna Kajzer-Bonk on 18-19 May 2020 using an i-ButtonTM thermohydrometer (Maxim Integrated Logger). Means with ± 95% confidence intervals are shown.*

Conclusions and implications

Extensively mown lawns and flower meadows in Krakow are a great alternative to a monoculture of intensively mown lawns, whose ability to absorb pollutants is much lower. Extensive management of green areas in the city is a solution that has many advantages over intensive management. It positively influences the landscape and local climate, is colorful and species rich, encouraging passers-by to interact and observe nature. The dense vegetation and variety of plant species of extensively managed lawns and meadows greatly enhance air-purification in comparison to intensively mown lawns. Unmown lawns and meadows have produced habitat for insect pollinators in Krakow.

A good practice that is becoming increasingly popular (Noordijk et al., 2009) is to divide green spaces into a recreational part, in which grass is mown regularly, and a much less intensively used part, where grass is mown infrequently. This strategy turns lawns into a diverse mosaic with more species, food sources and animal shelters (Kajzer-Bonk and Kierat, 2020). It is worth emphasizing how much semi-natural, high quality environment city dwellers gain only by reducing the frequency of lawn mowing.

References

Edmondson J., Stott I., Davies Z., Gaston K.J., Leake J.R. (2016) Soil surface temperatures reveal moderation of the urban heat island effect by trees and shrubs. *Scientific Reports* 6: 33708. https://doi.org/10.1038/srep33708

Kajzer-Bonk J., Kierat J. (2020) Efekt (braku) kosiarki. Nauka dla przyrody, 16.06.2020.

Kapustka J., Budzyńska M. The use of various animal species for therapeutic purposes in Poland: current perspectives Acta Sci. Pol. Zootechnica, 19 (2), 2020, 3–10, DOI: 10.21005/asp.2020.19.2.01

Millennium Ecosystem Assessment (MA). 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington.

Noordijk J., Delille K., Schaffers A.P., Sýkora K.V. (2009). Optimizing grassland management for flower-visiting insects in roadside verges. *Biological Conservation* 142: 2097–2103. https://doi.org/10.1016/j.biocon.2009.04.009

Sehrt M., Bossdorf O., Freitag M., Bucharova A. (2020:) Less is more! Rapid increase in plant species richness after reduced mowing of urban grasslands. *Basic and Applied Ecology* 42: 47–53. https://doi.org/10.1101/805325

Sobczyńska K. 2014 Zieleń jako element współczesnego miasta i jej rola w przestrzeniach publicznych Poznania (rozprawa doktorska)

Szczepanowska H. B. 2007, Ekologiczne, społeczne i ekonomiczne korzyści z drzew na terenach zurbanizowanych, Człowiek i Środowisko 31 (3-4)

Woźny A. 2015 Wpływ warunków siedliskowych na stan zieleni przyulicznej, Polska Akademia Nauk, Oddział w Krakowie, Komisja Technicznej Infrastruktury Wsi, Nr III/1/2015

Zawartka J., 2013 (red) Bielańsko-Tyniecki Park Krajobrazowy, mini przewodnik, Wydawnictwo: Zespół Parków Krajobrazowych Województwa Małopolskiego, ISBN 978-83-7475-894-9

Internet sources:

https://en.wikipedia.org/wiki/B%C5%82onia

https://www.inyourpocket.com/krakow/planty_60717v

https://ncert.nic.in/textbook/pdf/lebo114.pdf

https://www.millenniumassessment.org/documents/document.286.aspx.pdf

https://www.nwf.org/Educational-Resources/Wildlife-Guide/Understanding-Conservation/Ecosystem-Services

SUMMER CAMPS SCIENCE

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Abstract

One of the forms of non-formal education in science is the organization of summer science camps. In such camps, it is desirable for pupils to learn skills that they rarely encounter at school. The Faculty of Science of Charles University has been organizing science camps for 10 years and in this respect one of the goals is to acquaint the participants of the camp, pupils aged 10 - 16, with the basics of scientific work. For this purpose, the participants of the camp implement in groups, under the guidance of an experienced lecturer, a scientific project in which they solve a specific problem within the selected topic (e.g. monitoring the occurrence of ticks). The results of their research are then presented at a conference in the form of a presentation of their poster, which summarizes results. This contribution deals with the process of work on selected projects, the degree of implementation of the research component and it also presents selected posters. The results show that the pupils are generally able to implement the projects, but not autonomously. The problem is not only determination of research goals, but also the planning of activities, determining the structure of the presentation or division of work in the group. Pupils also emphasize the effect of presentation, not the results and correct presentation of data. They can practically never estimate the application potential of their research. It turns out that the education of pupils in the given area is desirable.

Keywords: Summer science camps, Pupils´ project, pupils´ project workflow.

Introduction

The science subjects, especially Chemistry and Physics, are not the favourite subjects among Czech pupils and repeatedly, they occupy the bottom levels of many subject rankings (Höfer & Svoboda, 2006, Picková, 2012). In addition to that, interest of pupils to study science subjects has been constantly decreasing in the Czech Republic recently. With respect to that, and due to principal importance of science subjects for society, support and advertisement of the science subjects are becoming necessary. Consequently, many new activities promoting science and technical subjects have appeared. The activities are organized by broad spectrum of institutions as Ministry of Education, Youth and Sports of the Czech Republic, various youth organizations (DDMs – "Houses of Children and Youth", …), non-profit nongovernmental organizations (e.g. Tereza) etc. Many exceptional activities are organized by educational institutions, especially schools and universities providing secondary and tertiary education. The principal advantage of these institutions and their activities is that they can provide experts and appropriate technical and specialized support to ensure high professional quality of the activities. Faculty of Science, Charles University in Prague, as one of the front Czech science educational institutions, is also organizing many high-quality promotional activities supporting the science education. Majority of these activities are targeted to secondary school teachers and students, nevertheless, there are also few activities which are devoted to primary school pupils. Among these activities, science-oriented summer camps for children aged 9-15 also play an important role. These camps are designed for children interested in science and their goal is to support science education and provide children with meaningful content for their summer holidays, where they can pursue their hobby under the guidance of experienced instructors. More about the nature and organization of the camps can be found in the following article by Šmejkal et al (2016). One of the many activities that are carried out at the camp is also the activity called scientific project. Within this project, pupils should carry out a little research in their area of interest on a topic given by the lecturer - the leader of the project research team. The project leaders are staff and students of the Faculty of Science, Charles University, which organizes the camp. These project team leaders propose the topic, project objectives and procedures in the project elaboration, however they should try to leave the pupils a certain autonomy in the elaboration of the project, its methodology and especially in the interpretation and presentation of the results. The aim of the project is also to acquaint pupils with the structure of scientific work and the structure of a scientific text and presentation. Another goal of the project is to try to support and to develop scientific thinking of pupils. Pupils work on the project for 15 hours, the output of the project is a poster, which pupils present for 15 minutes (plus 5-10 minutes of discussion) at a special scientific conference organized within the programme of the summer camp. As mentioned, one of the goals of the project implementation is to support scientific thinking, so as carry out research, even that which has already been discovered, but use adequate research methods and presentation of results. Research should therefore include setting a clear goal within a given topic, choosing appropriate methods, and carrying out appropriate experiments, and then interpreting the data. The presentation should cover all the components of a regular presentation, i.e. the introduction, goals, methodology, results and discussion, and conclusion. However, conducting research on pupils requires the need to use a considerable amount of competences and skills so that the overall output is in line with our intentions. It is necessary not only to choose the appropriate goal, but also to adequately choose the research plan, its implementation, team organization, time organization, etc. It is a question of whether pupils are able to use all necessary skills in a limited time and whether the project leader is able to manage the team to ensure cooperation of members in the project team. This contribution is focused to monitor how pupils and their team leaders use scientific methods and procedures and how they implement them in their outputs and posters, which they then present at the final conference.

Methodology

To answer the above questions, we analysed and evaluated posters and pupils´ presentations during a scientific conference held within the summer science camp. Specifically, we searched for the presence of components of the scientific structure in the texts of posters and presentations (existence of rationale, introduction, goals, results and discussion, interpretation of data, and conclusions parts) and we also conducted semi-structured interviews with all project leaders. As part of our survey, we analysed 19 different posters and presentations, five focused on biology (Human anatomy, Geo-dendrological map of Běstvina area, Allergens, Parasites trematodas and great pond snails in Hlubošský pond, Creatures of Běstvina – animals in our vicinity), 7 on chemistry (Chemistry in games, Polymers around us, Radiation, Electrochemistry, Chromatography of Běstvina plants, The rich life of Maria Sklodowska Curie, Color chemistry – indicators and dyes), 3 on geography (Sun-dial, Life in the slums, Climate change), 1 on geology (Geology of the Moon), 1 on astronomy (The formation of the solar system) and 2 on physics (Super-human, Magnetism). The projects were treated by pupils in groups of 6 - 10 children (mixed, girls and boys together) aged 9 - 15 years (mixed in groups as well). The project leaders were students of 1^{st}–10^{th} semester or of Ph.D. studies in the relevant fields or fields focused on the teaching of the given field. In order for the pupils to be able to carry out the project and carry out all the necessary experiments to meet all the objectives set by the project, there are available two "in camp" improvised biology and chemistry labs (built in two log cabins). The biology lab is equipped by microscopes, refrigerators, cages, probes, sample containers, equipment for hydrology, autopsy sets, bio-samples, botanical, invertebrates and fungi exhibitions etc. The chemical laboratory has laboratory tables, water supply, distilled water supply, sinks, basins, low pressure filtration sets, all the laboratory glassware, metal equipment and plastics, hot plates, burners, safety equipment, selected probes and instruments, equipment for chemical analysis (pipettes, burettes, ...) etc. Equipment provided to pupils for poster preparation and presentation includes theory sources: wrapping papers, markers, pencils, pens, crayons, A4 and A3 papers, rulers, skewers, rubber bands, scientific papers, books and articles, textbooks, presentations, etc. Usage of computers, Internet, smartphones and tablets is not allowed (except theory part or data treatment related to the project expected outputs)!

Fig.1. Pupils working on project (left - poster preparation, right - presentation)

Fig. 2. Běstvina scientific conference (left – audience, right - expert jury)

Results and disscusion

Some examples of the analysed posters and outputs are shown in the Figures 3 - 6.

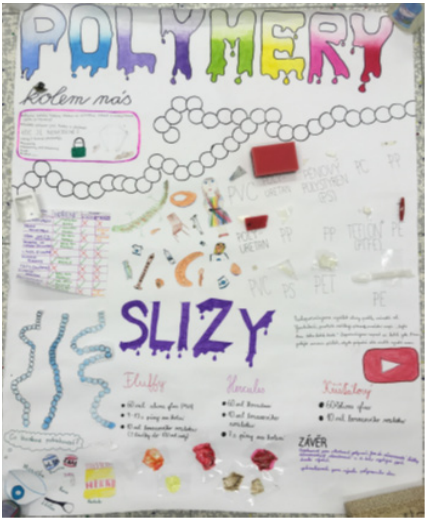

Fig. 3. Poster of the project "Polymers around us".

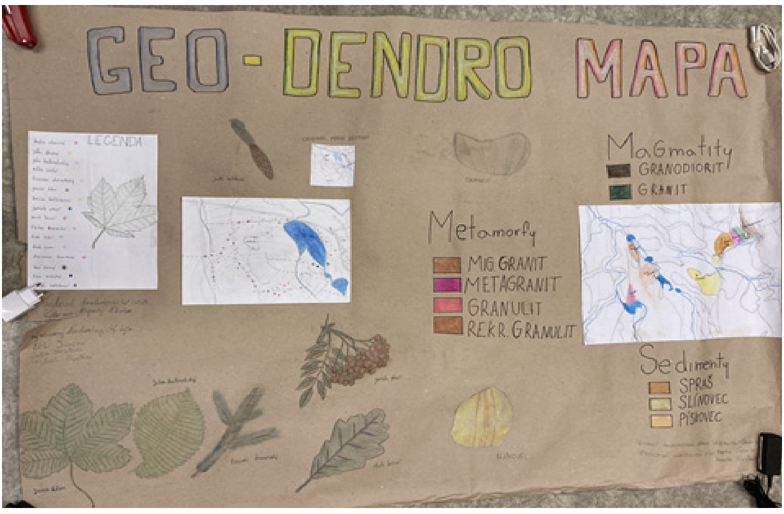

Fig. 4. Poster of the project "Geo-dendrological map of camp area".

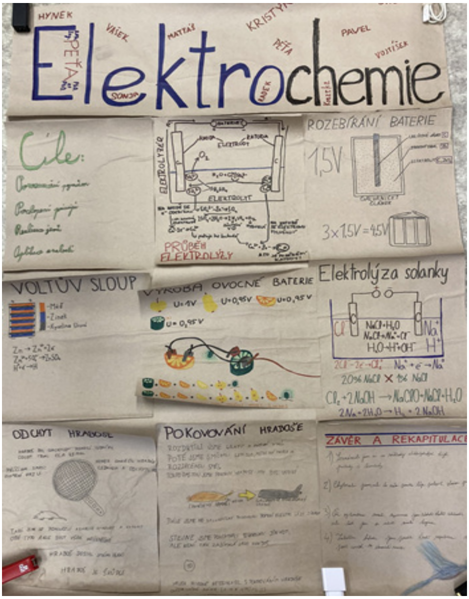

Fig. 5. Poster of the project “Electrochemistry”.

Fig. 6. Output of the project “Life in the slums” – model of a dwelling in a slum.

The results of posters analysis are summarized in Table 1:

Tab. 1. Analysis of posters - presence of parts of a scientific text/procedure

Name of the poster	Branch	Rationale	Introduction	Goals	Interpretation	Results and discussion	Conclusions
Human anatomy	Bi	No	No	No	No	No	No
Geo-dendrological map	Bi	No	Yes	No	No	Yes	No
Allergens	Bi	Yes	Yes	Yes	Yes	Yes	Yes
Parasites trematodas and great pond snails	Bi	No	No	No	No	Yes	No
Creatures of Běstvina – animals around us	Bi	Yes	Yes	No	No	Yes	No
Chemistry in games	Che	No	No	No	No	Yes	No
Polymers around us	Che	Yes	Yes	No	No	Yes	Yes
Radiation	Che-Fy	No	Yes	No	No	Yes	No
Electrochemistry	Che	No	No	Yes	No	Yes	Yes
Chromatography of Běstvina plants	Che-Bi	Yes	Yes	Yes	No	Yes	Yes
Maria Sklodowska Curie	Che-Fy	No	No	No	No	No	No
Color chemistry	Che	No	No	No	No	Yes	No
Sun-dial	Gg	Yes	Yes	No	No	No	No
Life in the slums	Gg	No	Yes	No	No	No	No
Climate change	Gg	No	Yes	No	No	No	No
Geology of the Moon	Ge	No	Yes	No	No	No	No
The formation of the solar system	As	No	Yes	No	No	No	No
Super-Human	Fy-Bi	No	Yes	No	No	No	No
Magnetism	Fy	No	Yes	No	No	Yes	No
Total (“No”)		14	6	16	18	8	15

The abbreviations for the branches presented in tables are: Bi = Biology, Che = Chemistry, Fy = Physics, Gg = Geography, Ge = Geology, and As = Astronomy. The results of presentations analysis are summarized in Table 2:

Tab. 2. Analysis of presentations - presence of parts of a scientific text/procedure

Name of the poster	Branch	Rationale	Introduction	Goals	Interpretation	Results and discussion	Conclusions
Human anatomy	**Bi**	**No**	**Yes**	**No**	**No**	**No**	**No**
Geo-dendrological map	**Bi**	**No**	**Yes**	**No**	**No**	**Yes**	**No**
Allergens	**Bi**	**No**	**Yes**	**No**	**Yes**	**Yes**	**No**
Parasites trematodas and great pond snails	**Bi**	**No**	**Yes**	**No**	**No**	**Yes**	**No**
Creatures of Běstvina – animals around us	**Bi**	**No**	**Yes**	**No**	**No**	**Yes**	**No**
Chemistry in games	**Che**	**No**	**Yes**	**No**	**No**	**Yes**	**No**
Polymers around us	**Che**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**Yes**
Radiation	**Che**-Fy	**No**	**Yes**	**Yes**	**No**	**Yes**	**No**
Electrochemistry	**Che**	**No**	**Yes**	**Yes**	**No**	**Yes**	**No**
Chromatography of Běstvina plants	**Che**-Bi	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**
Maria Sklodowska Curie	**Che**-Fy	**No**	**Yes**	**No**	**No**	**No**	**No**
Color chemistry	**Che**	**No**	**Yes**	**No**	**No**	**Yes**	**No**
Sun-dial	**Gg**	**No**	**Yes**	**Yes**	**No**	**Yes**	**No**
Life in the slums	**Gg**	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**
Climate change	**Gg**	**No**	**Yes**	**No**	**No**	**No**	**No**
Geology of the Moon	**Ge**	**No**	**Yes**	**No**	**No**	**No**	**No**
The formation of the solar system	**As**	**No**	**Yes**	**No**	**No**	**No**	**No**
Super-Human	**Fy**-Bi	**No**	**Yes**	**Yes**	**No**	**Yes**	**No**
Magnetism	**Fy**	**No**	**Yes**	**No**	**No**	**Yes**	**No**
Total ("No")		**17**	**0**	**12**	**17**	**5**	**17**

We can observe that the analysis of presence of the parts characteristic for scientific text/presentation in presentations copies the results of poster analysis. Nevertheless, there are some differences, in some cases. Overall, however, it can be said that during the presentation, pupils do not follow the structure of the poster very much and often mention what is not stated on the poster and, less often, vice versa, in the presentation do not list all the data on the poster (for example the poster focused on allergens). The scientific structure of the presentation and the poster is rather an exception (evident only in 2 presentations and 1 poster). Pupils very often omit important parts of a typical scientific presentation in their presentations and posters, in particular they do not justify why they carry out the research or output (rationale, goals), interpret the data little and only in few cases present conclusions from their research or work. Most posters and presentations are rather informative, so pupils do not find out anything "new", they only present interesting data for them from various sources. Surprisingly, in many cases data were collected (e.g. in the case of the Geology of the Moon project, photographs of the Moon were taken and printed, in the case of the Geo-dendrological map project, quantitative data on the number of woody plants were obtained, etc.), but not interpreted in any way and they were not presented on the poster (e.g. Fig. 4) or during the presentation. The interviews with project leaders showed some possible reasons why pupils do not follow the scientific structure of the presentation (or of a poster). In some cases (ca 1/5), the project leaders do not consider necessary and important to follow the scientific structure of their project. They usually justify it by saying that if they tried to follow this structure, it would not be fun for the pupils (represented, for example, by the statement: "Children should have fun at the summer camp "), or they do not consider the pupils' abilities sufficient for the scientific elaboration of the project, and therefore they do not even try to do so (represented by statement: "Children would not be able to do this, they are too small for that"). However, majority of project leaders tend to guide pupils to the scientific structure of the project and its presentation, but they encounter several obstacles and problems that they did not anticipate for the project treatment. Addressing these obstacles is time consuming and consequently leads to a lack of time for the actual processing of project objectives and, as well, to a lack of time for instructions for the actual processing of the poster and preparation of the presentation. The project leaders mention the most that pupils are not very autonomous and lack the necessary skills, they do not like theory (represented by statement: “Pupils say that the theory is boring …”), they are not able to determinate goals of research (“We don’t care what we do”) and it is very difficult to follow them. Pupils also are not able to plan their activities according their research goals (“Usually, they want to collect the data and measure more and more samples, but they leave no time for their evaluation. Then it is not enough time to finish the poster on time”), they are not able to cooperate and they are not able to organize work in groups. As well, division of roles in the team is problem (“Pavel drew all the attention to himself and constantly divides the tasks, because he is a bit self-centred, but part of the team does not want to fulfil the tasks set by him, even if it makes sense.” or “I don’t know what task to give to the smaller children. They cannot do anything. But if they don’t get the job, they’re angry.”). During the presentation, the pupils also often emphasize the effect of presentation and try to present the facts that they were more interested in, but not discovered by them, rather than the results and correct presentation of their own data and results. On the other hand, almost all the project leaders emphasize that the pupils are very motivated and creative in time of project and posters treatment (especially, see Figures 3 and 6). Children try to bring new ideas (albeit isolated and without justification), they are mostly very active and motivated, they work with interest and pleasure and do not hesitate to spend extra time on the poster and presentation treatment, if possible (for example, they prefer project processing over sports activities or sleeping). They care very much about the final poster look and about the presentation and try to process them as best they can and try to achieve a better result than other teams. It is thus clear that the project being developed at the camp is a welcome activity. For us, camp organizers, the results of the survey show that our requirements for the elaboration of a scientific project (containing scientific work procedures and scientific presentation of results) within the summer camp may be too great a challenge for pupils, especially in a relatively limited period of time. It is also necessary to train project leaders more so that they can more identify themselves with the need for scientific work in project elaboration, be given greater authority to intervene in pupils’ ideas and better manage team organization and project progress. At the same time, projects should be more realistic in terms of the amount of collected and interpreted data and determined objectives.

Conclusion

The analysis shows that our goal, i.e. to educate pupils during the summer camp regarding scientific thinking and scientific presentation of their results, is not fully fulfilled. There are several reasons for that. The main one is the insufficient readiness of pupils from their primary schools and grammar schools, where teacher-oriented teaching predominates, and the pupils' own activity is not very supported. Because scientific work necessarily uses other abilities and skills (e.g. the need for constructive communication, teamwork, scientific thinking etc.), which are not very developed in school teaching, the effort to educate pupils in the field of adequate implementation of principles of scientific work and presentation also encounters other difficulties associated with poor communication in the team, inappropriate division of roles, improperly processed project timeline and work organization, etc. As a result, it is necessary to pay more attention to the mentioned problem areas. It can lead to more efficient project work and save time that can be spent processing and interpreting data and presenting them. In a number of cases (but fortunately in the case of a significant minority) the implementation of the principles of scientific work and scientific presentation fails in the roles of project leaders who do not want to lead the elaboration of projects scientifically because they do not consider it fun enough or do not trust children's ability to work scientifically. On the other hand, the positive news is that most children are motivated and very creative when working on a project. Thanks to their enthusiasm and creativity, this creates graphically very nice posters and presentations with a significant didactic value, which can inspire others and can serve as successful teaching aids. It is gratifying news that the children participating in the camp do not lack enthusiasm for science and can pass it on to others, which is in many respects the most important thing that the camp and the implemented project can give them. Although the incorporation of scientific work methods and presentations is proving to be not very successful in project elaboration, there is no doubt that pupils are still educated in the field, as they receive important information in feedback from most of their project leaders as well as from jury and other leaders during their conference. The results also show that pupils enjoy the project treatment and consider their outputs to be important. So as, it can be assumed that with changes in the organization of the project treatment, it is realistic to gradually move towards greater use of the principles of scientific work and presentation in pupils‘ presentations and posters in future.

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References

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

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

Šmejkal, P., Šmejkalová, M., Sutrová, V., Freyerová, K. & Míková, Z. (2016). Science Summer Camps for Children - How We Do and How Should We Do? In: Cieśla, P., Kopek-Putała, W., Baprowska, A. (Eds.). Proceedings of the 7th International Conference on Research in Didactics of the Sciences DidSci 2016. 1st issue. Kraków, Pedagogical University of Kraków, pp. 147-149. ISBN 978-83-8084-037-9

INVESTIGATION OF ENVIRONMENTALLY CONSCIOUS BEHAVIOR AMONG PEDAGOGICAL STUDENTS OF J. SELYE UNIVERSITY IN SLOVAKIA

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Abstract

The aim of this pilot survey was to form a positive attitude towards sustainability among pedagogical students. From the three components of attitude (cognitive, affective, behavioral), we focus on the analysis of data on environmentally conscious behavior in our present presentation. In October 2019, 224 full-time pedagogical students (130 kindergarten teachers, 30 teachers, 64 biology teachers) participated in the cross-sectional study. A significant number of the interviewed students correctly interpret the responsibility of humanity for the state of the Earth and the values of nature. However, the need to significantly reduce the level of consumption in welfare societies to avoid an ecological crisis is not an acceptable position for all students. The proportion of uncertainties about the Earth's sustainability claims was close to 50%. One-third of students believe that health- and environment-conscious behavior characterizes their everyday lives, and two-thirds consider themselves only partially conscious. We consider one of the main tasks of our teacher training to show our students and make them realize how important is to develop environmentally conscious behavior that recognizes wide problems of our times and make them sensitive to them. They should be able to actively participates in their solution and pass them to the future generation.

Keywords: attitude testing, health and environment conscious behavior, teacher training,

The context and purpose of the framework

Environmental problems currently affect many areas of people's lives (ecological, social and economic). The consequences of these problems are extreme temperature fluctuations, strong storms combined with floods alternating with periods of drought, and also devastating, a racial decline in fauna and flora, all of which testify to human's misuse of nature (Havas, 1993).

Experts on global environmental issues and environmental education warned us a few years ago that there was a so-called generation bomb ticking. The point of the warning is that when our children realize that the beautiful new world promised by adults, their parents, their teachers means polluted water, polluted air, exhausted sources of material and energy, they will be held accountable for our promises (Havas, 2002). In response to this, a human rights declaration for future generations was published in 2004, which includes the following text.

"We, the people of the future, like the twenty thousand generations that preceded us, are shaping the right to breathe clean air, drink clean and free-flowing water, swim in life-rich water, and grow our plants in rich, life-filled soil. We are shaping the right to inherit a world free of toxic chemicals, nuclear waste and genetic contamination. We shape the right to walk in unspoilt natural surroundings and feel respected when we meet a wild animal. We grant the same rights and privileges to future generations. We do this in the sacred hope that the human soul, the human spirit, will live forever" (Kiss & Zsiros, 2006).

We need to realize that the generation bomb is indeed ticking, as we are no longer able to fully comply with the requests that our children are asking of us in the lines quoted above. For this bomb not to explode, we need to raise it. To educate the rising generations not to exacerbate the problems created so far, to educate them to be able to look for solutions to the problems they have and to educate them not to make the mistakes we have made.

The main question of environmental education is whether we can take responsibility for our actions and compromise between our needs and the possibilities of nature for the benefit of future generations (Kancír & Suchá, 2013). An environmental attitude is a set of beliefs, emotions, and behavioral intentions that an individual thinks about environmentally friendly actions and issues (Schultz et al., 2004).

To establish this, a number of scales have already been developed, e.g. the New Environmental Paradigm Scale (NEP), Inclusion of Nature in Self Scale (INS), Connectedness to Nature Scale (CNS), or Environmental Motives Scale (EMS) (Kráľ, 2014), which are mapped to infer environmental awareness. Of these, NEP is indeed one of the most common and popular measurement tools (Bernstein & Szuster, 2019).

Methods

Our main research question was whether there is a positive trend in environmental attitudes among Generation Z teacher candidates. In addition, we formulated the following hypotheses regarding the cognitive (emotional), emotional (affective), and behavioral (conative) components of environmental attitudes. We hypothesized that in the Decade of Education for Sustainability (2004-2015), youth socializing in public education

- is aware of the Earth's global environmental problems,
- is emotionally attached to the living space that determines it,
- realistically sees human's place in the biosphere,
- realistically sees the impact of man on the biosphere, the consequences of human activity,
- has a positive will to address local environmental problems,
- its commitment is demonstrated by environmentally conscious behavior,
- the institution of teacher training has a decisive role in shaping its environmental attitude.

Our study is a pilot study with descriptive, primary, cross-sectional, quantitative elements.

Our cross-sectional questionnaire survey entitled "Environmental Attitude" took place in October 2019 at the Department of Biology, Faculty of Teacher Education, Selye János University (SJU) in Slovakia. Kindergarten, and biology teacher students who attended one of the department's classes during this period were included in the sample. It took 15 minutes to complete the questionnaire based on our preliminary survey. Instructors orally explained the purpose of data collection to students and assured them of data confidentiality. A total of 224 students participated in the non-representative research. The self-administered, anonymous questionnaire contained 52 questions. Socio-demographic variables included age, in which we indicated three age group categories (18–25 years, 26–34 years, over 35 years), gender (male/female), name of current studies (biology teacher, kindergarten teacher, teaching major), department (full-time, correspondence), grade, type of settlement (capital, city, village), place of residence (apartment, house with garden). We also assessed the financial situation of the family (better than average, average, worse than average).

The assessment of environmentally conscious behavior was assessed on the basis of the answers to the 20 questions we compiled (on a 3-point scale, yes, no, in part). Our Paradigm Questionnaire was based on a 15-item Likert-scale test translated by the New Environmental Paradigm (NEP).

The first NEP test was developed by Dunlap and Van Liere in 1978, which was revised in 2000 and the original 12 statements were modified to 15. The official new name was changed to New Ecological Paradigm (Van Liere et al., 2000). Using their method, we can explore the composition of environmental attitudes. Students had to decide on a five-point scale how much they agreed with the ideas contained in the statements. (Each number refers to the false statement, the number five is true, so you agree with it.) In our processing, the category "agree" means the numbers four and five, the category "uncertain" means the number three, those who disagree mean the numbers one and two on the Grade Likert scale.

The NEP test contains five groups of statements. Statements 1, 6 and 11 are related to the sustainability of the Earth, and statements 3, 8 and 13 are related to the equilibrium state of our environment. Questions 2, 7 and 12 deal with the role of man in the biosphere, questions 4, 9 and 14 focus on the transformation of nature, and then questions 5, 10, 15 examine the extent to which students perceive the ecological crisis.

In addition to the 15 questions in the New Environmental Paradigm Questionnaire, there were two other self-edited questions on human responsibility.

Data were analyzed using IBM SPSS 26.0 statistical software. The values obtained during the descriptive statistical analysis of the NEP questionnaire were reported in our previous study (Darvay et al., 2020). In the present study, we examined the variables of the NEP questionnaire as well as the issue of responsibility, action, and awareness in the analyzes.

Results

In our study 95% of the surveyed students were between 18 and 25 years old, most of them were kindergarten teachers (58%), the proportion of biology teacher students was 27%, and the proportion of teacher students was 13%. All students study full-time. Exactly 90% of the answering students were women. The majority of teacher candidates are second- (35%) and third-year students (38%). Nearly two thirds of the students live in villages, 40% of them living in cities and capitals were not included in our sample. 78% of the students live in a house with a garden and 22% in an apartment. In the question concerning the financial situation of the participants three-quarters of the respondents considered it average, 18% considered the financial situation of their family to be better and 5% worse.

Results of the New Environmental Paradigm Questionnaire (NEP)

EARTH HOLDING CAPACITY

The statement that the number of humanity is approaching the limit of the Earth's carrying capacity (Statement 1) was considered correct by 75% of students (grades 4-5), 20% was uncertain. The Earth's resources are abundant, we just need to be able to use them (statement 6) statement was considered true by half of the respondents, one third was uncertain, 14% disagreed with this statement (grade 1-2). Claim 11 that the Earth is like a spaceship with a finite number of space and resources, shared opinions. More than half of the students agreed with this, 32% said it was not true, the rest were uncertain about the statement.

THE EQUILIBRIUM STATE OF OUR ENVIRONMENT

The majority of students (88%) indicated agreement with the following statement, if a person intervenes in the processes taking place in the environment, it can have serious consequences (statement 3). Only 10% were unsure, 2% considered this statement to be false. Statement 8 that the balance of nature is strong enough to withstand the effects of industrialized societies was judged to be incorrect by 70% of students, with 25% uncertain.

The majority of students (70%) agreed that the balance of nature is very sensitive and easily upset (statement 13). Only 24% were unsure, 6% considered the statement to be false.

THE ROLE OF HUMANITY IN THE BIOSPHERE

The first of these statements, that people have the right to change the natural environment as they wish (statement 2), was a category of disagreement among 57% of students. 36% of them were uncertain, 15% of them considered the statement to be correct.

The most consistent positive response was given by students to the following statement (92%) that plants and animals have the same right to life as humans (statement 7). 6% of respondents were insecure. The majority of students (81%) considered statement 12 that it is man's job to rule nature to be false. 13% of the students were unsure, 6% considered the content of the sentence correct.

OUR RELATIONSHIP TO THE BIOSPHERE, TO THE TRANSFORMATION OF NATURE

Human ingenuity does not ensure that the Earth remains livable (statement 4) 48% of students thought it was correct, 42% were unsure.

Despite our special abilities, we must live in obedience to the laws of nature (9th) statement was considered true by half of the students, 44% were uncertain, and 6% were false. Statement 14 argues that humanity needs to know how the processes of nature work in order to control them. 72% of students disagree with this, 8% agree, 20% are uncertain.

PERCEPTION OF THE ECOLOGICAL CRISIS

86% of respondents agree with the statement that people irresponsibly destroy the environment (Statement 5). 10% of the surveyed students are unsure, 4% say the statement is false. According to statement 10, the so-called the ecological crisis (i.e., that wildlife is in danger) that humanity is facing is not an exaggeration. 65% of students think the statement is correct, 13% are uncertain, 22% consider it to be false.

With the last statement that if everything continues as before, we will soon be part of a major Ecological Disaster, 90% of students agree. 4% of the students surveyed disagree with this statement, 6% are unsure.

THE MATTER OF RESPONSIBILITY, ACTION, AWARENESS

Regarding the issue of human responsibility, we can make the following statements regarding the values measured on the five-point Likert scale. Exactly 81% of students fully agreed with the statement "Humanity is responsible for the state of the Earth, for the values of nature". However, in the case of the statement "A significant reduction in the level of consumption in welfare societies is needed to avoid a crisis", only 32% said they fully agreed with this statement (Fig. 1).

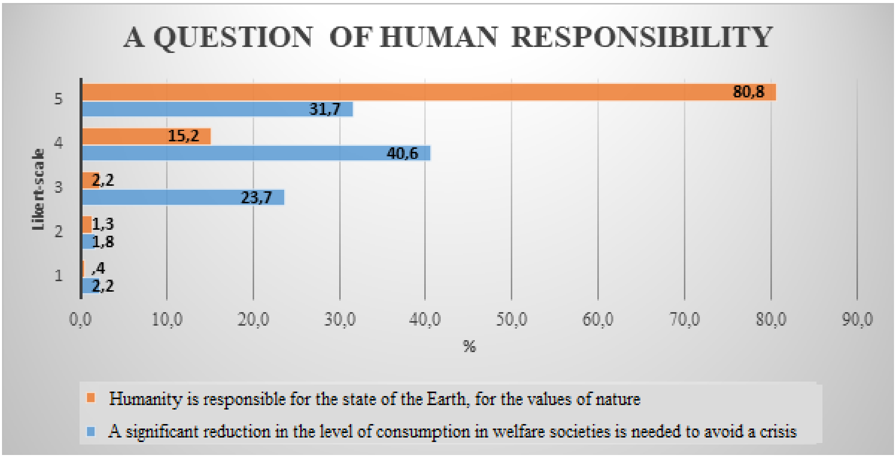

Fig. 1. A question of human responsibility.

In addition to the general assessment of responsibility, the weight of one's own responsibility is important. We asked them a question what can we do for a sustainable environment and for our own health? A significant proportion of students in the study sample gave a positive answer that we can shape our lifestyle positively in regards of sustainable environment and health. Only 15% said they could do little for a sustainable environment, 3% said they could do little for their own health (Fig. 2).

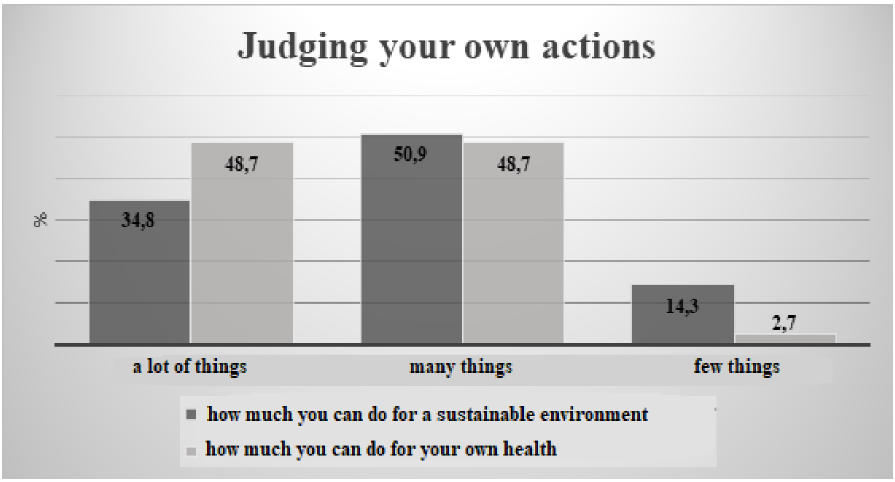

Fig. 2. Judging your own actions.

At the end of the questionnaire we asked the question, how much do you consider yourself to be environmentally conscious and health conscious? The set of questions probably influenced the answer because only 30% of the students considered themselves conscious, this is true for both questions and most of them only partially assessed themselves as conscious.

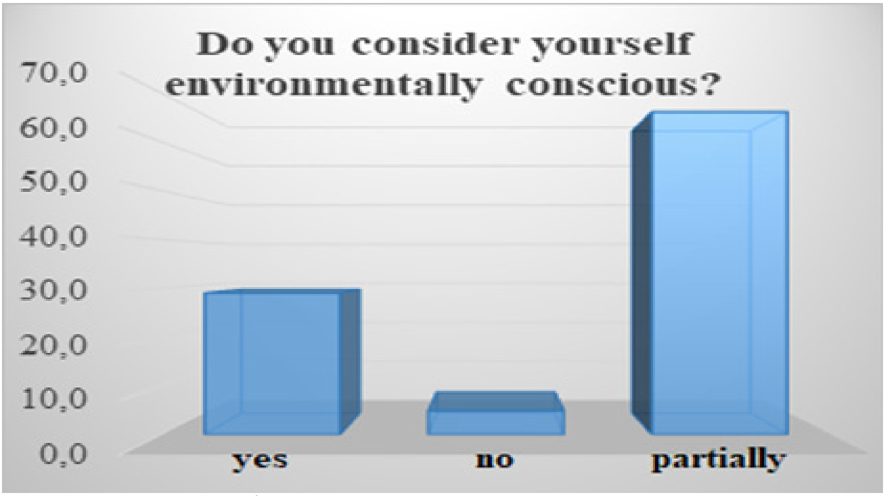

Fig. 3. Environmental consciousness.

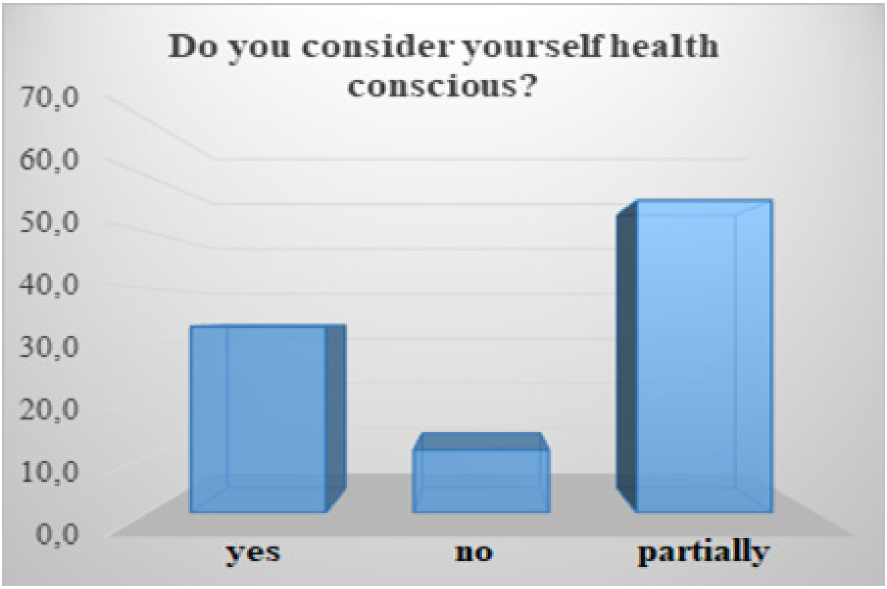

Fig. 4. Health consciousness.

When we asked the students what they think about their health now and how it will be 25 years later, we received an interesting answer. Most students (48%) think that even in 25 years from now, their health will be the same as it is now or very similar, and they do not think their health will be affected by environmental issues. On the other hand, they are fully aware of the negative effects of environmental issues on people and nature, but they still don't think it will have impact on their lives. This is a presumption that should be emphasized in the process of environmental education so that students are even more aware of environmental problems and their impact on their own lives now and in the future.

Conclusions and implications

There is no longer an untouched natural environment on Earth. Man has populated much of the Earth, and the impact of his activities is having an impact on the entire planet. Even now, all the inhabitants of the Earth are constantly using the Earth's natural resources. They are constantly deforesting all over the world, extracting minerals and energy sources, thereby eroding the soil, polluting the air and water, and producing hazardous waste, causing the most intense natural degradation in the history of the earth. There is an increasing burden on nature to meet needs, leading to the deterioration of the natural environment, resulting in accelerating species extinction, the spread of deserts, the accumulation of herbicides, increasing health problems, famine and increasing impoverishment. Obviously, if this rate of natural destruction is not reduced, the systems that operate all of life on Earth could collapse.

The aim of environmental awareness-raising is to promote environmentally conscious behavior and a way of life that is responsible for the environment (Havas, 1993). Looking further, it aims to shape behavior, values, attitudes, emotional attitudes and to expand the knowledge that can be developed about the environment and society. All these efforts are aimed at the preservation and maintenance of the biosphere - and human societies in it - with the emotional, intellectual, aesthetic and moral foundation of nature, the built and social environment, and the system of human respect. (Havas, 2002)

Environmental education can be found at all levels of the education system, from kindergarten to PhD training. But the higher we go at the levels of education, the more the topic is narrowing. While environmental education in kindergarten is linked to almost all fields of education, in primary school it is associated mainly with environmental knowledge and later with science subjects. In high school, the subject is almost exclusively discussed in the teaching of biology, chemistry, and geography. In higher education, the teaching of knowledge on environmental protection and sustainable development is not yet fully developed, although the ongoing restructuring of higher education provides an opportunity for all students in science and technology to learn environmental knowledge among the basic subjects (Kiss & Zsiros, 2006).

The UN Decade of Education for Sustainability (2005-2014) was followed by the Comprehensive Action Plan on Education for Sustainable Development (ESD) (2015-2019) and the new ESD Framework for 2030 (2020-2030) builds on this. UNESCO, the United Nations World Organization for Education, which is responsible for coordinating the global education framework for 2030, among others, has set educational goals for the 17 sustainable development goals (UNESCO 2017, Könczey 2017, Mika & Tóth, 2016, Lükő, 2017).

According to this, the acquisition of the attitude and knowledge necessary for the growing generation, but especially for the intellectuals of the future, to make changes must become as widely known as possible.

For all students studying in higher education, even for students without science studies, it is essential to know and understand scientific concepts in the field of sustainability. The goal of education for sustainable development is to provide students with the knowledge, skills, values, and attitudes necessary for a more inclusive, just, peaceful, and sustainable world.

It has become inevitable to rethink the role of the educator. Teacher candidates need to be prepared to interpret the principles of sustainability in the local practice of their own school (institution) and to set an example in terms of environmentally friendly living and innovation. Be aware that their most important pedagogical tool is their own personality (Lányi & Kajner 2019).

Based on the survey of students surveyed in our research, all indications are that SJU teacher candidates understand the main problems and issues related to human impacts and climate change in the environment. However, they are not yet fully environmentally conscious in terms of their impact on their own environment. We consider one of the main tasks of our teacher training to show our students and make them realize how important is to develop environmentally conscious behavior that recognizes wide problems of our times and make them sensitive to them. They should be able to actively participate in their solution and like future teachers pass them to the next generation.

Therefore practical implications of this study should be as follows. Firstly, teacher candidates should receive adequate training, support and knowledge about environmental issues during their studies in order for them to understand them and later implement them to curriculum adequately. Secondly, assessment practices should incorporate new approaches that encourage students to evaluate environmental issues. Thirdly, students' knowledge about the environment should be up-to-date and teachers should be trained on the appropriate methods for teaching environmental topics. Fourthly, carefully developed textbooks and supporting instructional materials should be made available to all students and teachers in a timely fashion.

Finally, there needs to be a realization that environmental issues are not "supplements" of the curriculum in any school. Rather, they are integral components of the curriculum that should be taught, learned, and assessed as opposed to eliminated at the slightest hint of time pressure. The favorability of environmental attitudes among students indicates that most of these students will welcome the introduction of environmental topics in school curricula. This emotional involvement will make students receptive to instruction about the environment and they will be able to pass their knowledge to others and hopefully live more consciousness life with wide attitude towards environment and nature.

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References

Bernstein, J. & Szuster, BW. (2019): The new environmental paradigm scale: Reassessing the operationalization of contemporary environmentalism. The Journal of Environmental Education, 50 (2), 73-83,

Darvay, S., Nagy, M., Tóth Tar, É. & Balázs, P. (2020). Környezeti attitűd vizsgálat a Selye János Egyetem pedagógus hallgatói körében. In Tóth P. – Benedek A. – Mike G.– Duchon J. (szerk.): Fejlődés és partnerség a felsőoktatásban határok nélkül. Az I. Szakképzés és oktatás: Ma-Holnap Konferencia tanulmánykötete, 247-254. ISBN 978-963-421-810-4

Havas, P. (1993). *A környezeti nevelés néhány pedagógiai elve és területei. Új Pedagógiai Szemle, 1993. 10. sz. 12-21.*

Havas, P. (2002). A környezetvédelmi tudatformálás színterei és módszerei – internet reference - http://korlanc.ngo.hu (Last download: 2020.06.08.)

Kiss, F. & Zsiros, A. (2006). A környezeti neveléstől a globális nevelésig. A környezeti nevelés című könyvben (Szerk: Kuknyó János - A környezeti nevelés. Szabolcs-Szatmár-Bereg Megyei Önkörmányzat Megyei Pedagógiai, Közművelődési és Képzési Intézete, Nyíregyháza.) Nyíregyháza, MPKKI, 12-27. o.

Kancír, J. & Suchá, I. (2013). Škála Novej environmentálnej paradigmy ako výskumný nástroj v oblasti environmentálnej gramotnosti, Internetes forrás: https://www.pulib.sk/web/kniznica/elpub/dokument/Kancir1/subor/Kancir_Sucha.pdf (Last download: 2020.01.25.)

Könczey, R. (szerk.). (2017). Fenntartható fejlődési célok oktatása, UNESCO, EKE OFI Internetes forrás:http://ofi.hu/node/181079 (Last download: 2020.01.27.)

Kráľ, M., (2014). Environmentálna identita, environmentálne postoje a environmentálne zodpovedné správanie slovenských vysokoškolákov, Psychoprof, 2014, 293-302. ISBN 978-80-89322-16-9.

Lányi, A. & Kajner, P. (szerk.) (2019). A fenntarthatóság témaköre a felsőoktatásban. UNESCO Magyar Nemzeti Bizottság, ISBN 978-963-7364-09-9

Lükő, I. (2017). Oktatás és fenntarthatóság az ENSZ Fenntartható Fejlődési Célok (SDG 2016-2030) rendszere alapján. Holisztikus, rendszerszemléletű és multidiszciplináris megközelítések, EDU 7. évfolyam 3. szám Internetes forrás: http://epa.oszk.hu/02900/02984/00016/pdf/EPA02984_edu_2017_3_007-031.pdf (Last download: 2020.01.27.)

Mika, J. & Tóth, B. (2016). Az ENSZ Fenntartható Fejlődési Célok (2016-2030) környezeti vonatkozásai Héra Évkönyv, 549-569. Internetes forrás: http://hera.org.hu/wp-content/uploads/2014/02/HERA_evkonyv_kiegeszites20170615.pdf (Last download: 2020.01.27.)

Schultz, P. W., Shriver, C., Tabanico, J. J. et al. (2004). Implicit connections with nature. *Journal of Environmental Psychology*, 24, 31-42.

UNESCO (2017). Education for Sustainable Development Goals, UNESCO, Paris Internetes forrás: https://unesdoc.unesco.org/ark:/48223/pf0000247444 (Last download: 2020.01.27.).

Van Liere, K., Dunlop, R., Merting, A. et al. (2000). Measuring endorsement of the new ecological paradigm: a revised NEP scale. *Journal of Social Issues*, 56, 431-438.

THE DESIGN OF THE TWO-TIER TEST TO DIAGNOSE STUDENTS' CONCEPTIONS OF THE NATURE OF SCIENCE

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Abstract

Many researchers worldwide analyzed prospective secondary school science teachers' understanding of the nature of scientific knowledge (Métioui & Trudel, 2007; Lederman, 2007). This research fits into this perspective and aims to develop a two-tier test to diagnose the elementary and secondary pre-service teachers' attitudes about science (NOS). The test constructed can be used as an instrument for university science education teachers to evaluate their students' understanding of the NOS before teaching. We used a qualitative method tobuild the test. The development procedure had three general steps: constructing paper-pencil questionnaire about the NOS, identifying the students' understanding of the NOS, and two-tier test development. The paper-pencil questionnaire composed of 20 statement covered 5 themes each one composed of 4 statements: 1. The objectives of the science, 2. The Role of Measure, Experimentation and Theory in Science, 3. The Evolution of the Science (Continuity or Rupture), 4. The Logico-Mathematical Reasoning in Sciences, and 5. The Limits of Science and Technology. Analysis of the students' responses to the paper and pencil questionnaire enabled us to identify many representations like those listed in the review of international literature highlighted above. For eachtheme, we have retained four categories of conceptual representations, including which shared by many epistemologies and historians of science.

Keywords: Design, Two-tier-test, Nature of science, pre-service-teachers, elementary and secondary school

Background, framework, and purpose

Most research on didactics points out that elementary and secondary school teachers must include the nature of science (NOS) elements. This objective has been highlighted in the significant science curriculum worldwide since the eighties (Abd-El-Khalick & Lederman, 2000; Clough, 2018; Lederman and Lederman, 2019; Matthews, 2012). The NOS concern, among others, the study relative to the scientific community functionality and the nature of scientific knowledge (models, laws, and theories). These studies require knowledge of philosophy, epistemology, and the history of science. Lederman and Lederman (2019) point out that studying science's nature is to think about scientific literacy: "The nature of science is a multifaceted concept that defies simple definition. It includes aspects of history, sociology, and philosophy of science and has variously defined as science epistemology, the characteristics of scientific knowledge, and science as a way of knowing. Perhaps the best way to understand the nature of science is to first think about scientific literacy." Research in the fields of knowledge mentioned above shows that scientist does not have a unique brain, as was thought in the case of the famous physicist Albert Einstein. Scientists make mistakes and sometimes develop erroneous theories. However, it is crucial to note that some scientists' errors were the source of significant discoveries, and others slowed down the development of knowledge for several years or even several centuries (e.g., the caloric theory, the impetus theory; ether theory).

Most textbooks do not consider these considerations relative to the NOS (Lederman & Lederman, 2019; McComas & Olson, 1998). According to these studies, the textbooks convey a reductive image of the sciences about the approaches presented, the vocabulary used, or the historical elements introduced. Often only one person is mentioned concerning a given, most often famous discovery. Besides, the findings seem instantaneous, fixed on a precise date, and arising from an accurate idea or a significant experience, and therefore far from the complexity of scientific activities. Centered on the discovery of laws, they obscure the importance of techniques and science's social, economic, and cultural dimensions. The diversity of issues pursued by scientists is neglected as theoretical, experimental, technical aspects. As well the epistemological and metaphysical considerations. For example, the probabilistic interpretation of the properties of matter at the particle scale posed a problem for Einstein not on the mathematical level but rather on the metaphysical level "*God did not play dice*." Also, teachers' and students' conceptual reasoning of the nature of science is problematic (Bell et al., 2003; Maurines & Beaufils, 2010; Métioui & Trudel, 2013, 2015). Maurines and Beaufils emphasize that many science teachers are not aware that one of the challenges of learning science is epistemological. Even those for whom this dimension is important tend to favor the acquisition of knowledge and know-how. Besides, many teachers share an outdated view of science (empirical-inductive and realistic "naive") and transmit it to students through their practices (Lederman, 2007; OECD, 2005). From this perspective, many researchers worldwide analyzed prospective secondary school science teachers' understanding of the nature of scientific knowledge (Lederman, 2007). This research fits this perspective and aims to develop a two-tier test to diagnose the elementary and secondary pre-service teachers' attitudes about the NOS. The test constructed can be used as an instrument to evaluate the student's understanding of the NOS before teaching.

Methods and analyses

We used two stages to construct the two-tier diagnostic test to evaluate the pre-service teachers conceptions about the nature of science. Below we present the methodology used in each stage.

First stage: Constructing the first tier

Paper-pencil questionnaire

The objective of the first step was to construct the first-tier questionnaire to assess students' conceptual representations of the nature of science and technology. We used a qualitative approach to build a paper and pencil questionnaire made up of 16 statements. Students were asked to indicate whether they agree, disagree, or do not know for each item. Then they had to justify their choice as best they could. The justification put forward by the student is methodologically necessary because its analysis makes it possible to infer its representation. The paper and pencil questionnaire covered four themes, and each theme contained four statements, as illustrated in table 1.

One hundred twenty (120) students completed the questionnaire electronically. Below are the instructions they received regarding the objectives pursued by the questionnaire they had to complete and return by email:

“Fill out the questionnaire to the best of your knowledge, without doing any research to obtain information on the question. Also, do not discuss with colleagues or any other person, because the objective pursued is to precise the previous knowledge about the development of science and technology. Anyone who checks their choice by explaining it will have the score indicated.”

Table 1. Paper-pencil questionnaire

Theme 1: The role of measurement, experimentation, and theory in science	
Statement 1	Scientists use their sensory apparatus (e.g., touch, smell, hearing) to develop their theories.
Statement 5	To develop a scientific theory, one must do some experiments first.
Statement 8	A new scientific theory replaces another one, must predict more experimental results.
Statement 14	To study the properties of the phenomena, the scientists first do some measures; and then define the concepts.
Theme 2: The logico-mathematical Development in Sciences	
Statement 2	The scientists present their theories under the format of logico-mathematical reasoning.
Statement 6	A scientist must always argue in a coherent and just manner.
Statement 9	The new scientific concepts result from the application of logical thought.
Statement 11	In the development of his thought, the scientist excludes all recourse to his religious convictions.

Theme 3: The evolution of the science: Continuity or Rupture	
Statement 3	The direction followed by today's science was determined by orientations taken by previous generations of scientists.
Statement 7	The scientific problems of the past are bound intimately to those of today.
Statement 13	The scientific progress results in an improvement of the scientific theories.
Statement 15	Tomorrow's scientific theories will be the extension of today's theory.
Theme 4: Objectives of science (Reality - Nature - Truth)	
Statement 4	The scientist is primarily motivated by the search for truth.
Statement 10	The objective of science is to study natural phenomena.
Statement 12	By observing the fall of an apple, Newton discovered the law of gravitation.
Statement 16	To know the "truth," one must refer to science.

Data analyses

First, we have compiled for each statement the number of students answers in every three categories (In agreement - I don't know and 3. In disagreement). The percentages of responses to two statements of each theme are presenting in table 2 as an illustration.

Table 2. Percentages of answers of the students

Theme 1: The role of measurement, experimentation, and theory in science		
Statement 5: To develop a scientific theory, one must do some experiments first.		
In agreement : 78%	I don't know : 6%	In disagreement : 16%
Statement 14 : To study the properties of the phenomena, the scientists first do some measures; and then define the concepts.		
In agreement : 53%	I don't know : 29%	In disagreement : 18%
Theme 2: The logico-mathematical Development in Sciences		
Statement 6: A scientist must always argue in a coherent and just manner.		

In agreement : 69%	I don't know : 7%	In disagreement : 26%
Statement 11 : In the development of his thought, the scientist excludes all recourse to his religious convictions.		
In agreement : xx%	I don't know : xx%	In disagreement : xx%
Theme 3: The evolution of the science : Continuity or Rupture		
Statement 3: The direction followed by the science of today was determined by orientations taken by previous generation of scientists.		
In agreement : 76%	I don't know : 8%	In disagreement : 16%
Statement 13 : The scientific progress results in an improvement of the scientific theories.		
In agreement : 86%	I don't know : 1%	In disagreement : 19%
Theme 4: The objectives of science (Reality - Nature - Truth)		
Statement 4: The scientist is primarily motivated by the search for truth.		
In agreement : 67%	I don't know : 11%	In disagreement : 22%
Statement 12 : By observing the fall of an apple, Newton discovered the law of gravitation.		
In agreement : 59%	I don't know : 17%	In disagreement : 24%

For most students, statements 5, 11, 3, and 4 are correct (78%, 69%, 76% and 67%). However, by analyzing the explanations put forward, we identified several categories of explanations. So, for each statement, we have identified different categories of representations following the advanced explanations.

Second stage: Constructing the second tier

The second tier includes a multiple-choice set of reasons for the answer to the first tier. We have retained four conceptual representations inferred from the analysis of the students' explanations. Three of them do not conform to those shared by most contemporary epistemologists and historians of science, as indicated in the framework. In tables 3 and 4, we give examples of the two-tier constructed relative to one question for each theme.

Table 3. Two-tier diagnostic test: Themes 1 and 2

Theme 1: The role of measurement, experimentation, and theory in science
Question 5: To develop a scientific theory, one must do some experiments first. ❒ In agreement ❒ I don’t know ❒ In disagreement Which of the following explanations justifies your answer? ❒ By experimenting, scientists formulate theories, much like Newton's case, who experienced the apple that fell from a tree. It was after this that he was able to develop an argument, then the law of gravity. ❒ Experimentation is part of the scientific process. Thus, before arriving at a theory, one must research and experiment to find results that will conclude. ❒ It is possible to develop a scientific theory without having to do experiments to prove it. The experiments serve, slightly to deepen a scientific theory. ❒ While it is true that scientists must perform experiments to develop a scientific theory, this is not the first step. We should first ask ourselves a question, make observations, and pose hypotheses. ❒ Other. Please write: ____
Theme 2: The logico-mathematical development in sciences
Question 11: A scientist must always argue in a coherent and just manner. ❒ In agreement ❒ I don’t know ❒ In disagreement Which of the following explanations justifies your answer? Scientists are humans, and as humans, we have the right to make mistakes. It is through error that we learn and discover best. ❒ A scientist must think fairly and consistently because otherwise, he would be doing it arbitrarily, and it would be his opinion. If a scientist expresses his opinion, it is not a scientific fact, because nothing can prove it. ❒ A scientist must think fairly and consistently because otherwise, he would be doing it arbitrarily, and it would be his opinion. If a scientist expresses his opinion, then it is not a scientific fact, because nothing can prove it. ❒ Coherently explaining certain concepts is difficult (e.g., parallel universes, time travel) when it is impossible to observe them. ❒ If the scientist wants his results to be understood by all, he must think coherently. ❒ Other. Please write: ____

Table 4. Two-tier diagnostic test: Themes 3 and 4

Theme 3: The evolution of science: continuity or rupture
Question 3: The direction followed by the science of today was determined by orientations taken by previous generation of scientists. ❒ In agreement ❒ I don't know ❒ In disagreement Which of the following explanations justifies your answer? ❒ Discoveries made by ancient scientists allow us to make other discoveries today. Our developments evolve, but they start with a notion discovered by an earlier generation of scientists. The advancement of science occurs linearly. Scientists build their knowledge on considering the theory, concepts, and observations made by our predecessors. It is a legacy. Science today does not live in the past. On the contrary, it is incredibly scalable and tends to recreate itself as a new kind of science. ❒ Technological advances and the discoveries that have been made in recent years have significantly altered the directions taken by previous generations of scientists. They are, therefore, no longer the same and are evolving just like science. ❒ Other. Please write: ____
Theme 4: The objectives of science (Reality - Nature - Truth)
Question 4: The scientist is primarily motivated by the search for truth. ❒ In agreement ❒ I don't know ❒ In disagreement Which of the following explanations justifies your answer? ❒ The primary motivation of the scientist is to find answers to natural phenomena. Thus, the truth constitutes the most valid reason to respond most faithfully to the observed natural phenomena. Indeed, the field of science studies natural phenomena to obtain a true answer. ❒ The search for truth is the essence of a scientist's work. Its purpose is to prove and find out why a hypothesis is correct, what explains it, and under what circumstances. ❒ The scientist seeks to find answers to phenomena rather than attempting to find the truth. ❒ The scientist is motivated by the search for explanations and theories, which constitute the truth. Truth relates to everything around us. Science seeks to explain the truth. How did humans come to earth? There are many theories, but which is the real one? ❒ Other. Please write: ____

Conclusions and implications

Analysis data of the paper and pencil questionnaire enabled us to identify the students' conceptual representations about the NOS relatively to 4 themes (*The role of measurement, experimentation, and theory in science - The logico-mathematical Development in Sciences - The evolution of science: continuity or rupture - The objectives of science: Reality - Nature - Truth*). Some of their representations were like those listed in the review of international literature highlighted above. The reasoning identified constituted the core of the two-tier test composed of 20 questions. In each item, we have retained four categories of conceptual representations deduced from the data analysis relative to the paper-pencil questionnaire.

The test developed will allow pre-service teachers to quickly precise their conceptions on the nature of science. Analyzing the pencil paper questionnaire data enabled us to identify the students' reasoning about the NOS. Some of their understandings were like those listed in the international literature review highlighted above. Thanks to these results, we built a two-tier diagnostic test composed of 16 items. In each one, we have retained four categories of conceptual representations deduced from the data analysis relative to the paper-pencil questionnaire. The student must make a choice in which description justifies the veracity of the statement in question.

References

Abd-El-Khalick, F., and Lederman, N. G. (2000). Improving science teachers'conceptions of nature of science: a critical review of the literature. *International Journal of science education*, 22 (7), 665-701.

Bell, R., Blair, L., Crawford, B., & Lederman, N. G. (2003). Just do it? The impact of a science apprenticeship program on high school students' understandings of the nature of science and scientific inquiry. *Journal of Research in Science Teaching*, 40, 487-509.

Clough, M.P. (2018). Teaching and Learning About the Nature of Science. *Sci & Educ,* 27, 1-5 : https://doi.org/10.1007/s11191-018-

9964-0

Coppens, N., Rebmann, G., et Munier, V. (2009). Suivre l'évolution des conceptions des élèves en mécanique : développement et évaluation d'exercices informatisés, *Didaskalia*, 35, 37-58.

Lederman N. G. (2007). Nature of Science: Past, Present and Future. In Abell S.K. § Lederman N.G. (ed.). Handbook of research on science education, Lawrence Erlbaum associates, Londres. 831-879.

Lederman, N. G and Lederman, J. S. (2019). Teaching and learning nature of scientific knowledge: is it déjà vu all over again? *Disciplinary and interdisciplinary science education research*, 6(1), 1-9.

Matthews, M.R. (2012). Changing the Focus: From nature of Science (NOS) to Features of Science (FOS). In M. S. Khine (Ed.), Advances in Nature of Science Research: Concepts and Methodologies (pp. 3-26). Dordrecht: Springer Netherlands.: Springer

Maurines, L., and Beaufils, D. (2010). Un enjeu de l'enseignement des sciences: l'image de la nature des sciences et de l'activite scientifique. Comment y repondre grace a l'histoire des sciences et techniques? Actes du congrès de l'Actualité de la recherche en éducation et en formation (AREF), Université de Genève.

McComas, W.F. & Olson, J.K. (1998). The nature of science in international science education standards documents. In McComas (Ed.), *The nature of science in science education: Rationales and strategies* (pp. 41–52). Kluwer Academic Publishers: The Netherlands.

Métioui, A., & Trudel, L. (2015). Epistemological Rupture in the Discourse of High School Teachers: The Case of the Atomic Theories. LUMAT: Research and Practice in Math, Science and Technology Education, 3(4), 439-448.

Métioui, A., & Trudel, L. (2013). Conception of Quebec Students in Teacher Education Regarding the Construction Modes of Science Knowledge, *American Journal of Educational Research*, 1(8): 319-326. DOI: 10.12691/education-1-8-9.

OECD (2005). Declining enrolment in science & technology studies. Is it real? What are the causes? What can be done?

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