FOLIA 343

Annales Universitatis Paedagogicae Cracoviensis

Studia ad Didacticam Biologiae Pertinentia 11 (2021)
ISSN 2083-7276
DOI 10.24917/20837276.11.25

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Stepping (Designing) the process of pupils' writing chemical reactions' equations for other pupils

Introduction

The project method is one of the methods of education increasing the active participation of pupils - project participants in the implementation of the core curriculum for general education in Poland and around the world (Chałas, 2000; Rusek & Dlabola, 2013). The assumption of the project method is to implement the philosophy of pragmatism and cognitive constructivism. The pupil, in cooperation with other project participants, tries to find a method of solving a problem of their choice, using various sources of information. An important dimension of problem-solving is that the pupil builds the knowledge structure necessary to complete the task set by the team or to verify the analyzed hypothesis (Gołębniak, 2002). The project method allows students to take responsibility for their education. During the project implementation, they can also learn about their strengths and weaknesses. In chemical education, writing and balancing equations of a chemical reaction is a very important skill. This skill causes many problems for students (Paśko, Haduch, 1999). This is due to the fact that writing and balancing the equation of a chemical reaction requires about 40 consecutive steps (Paśko, Haduch, 2000; Nodzyńska, Paśko, 2008). In many cases, students are not aware of it (Nodzyńska, Paśko, 2010).

Methods and Materials

The project presented in this paper was carried out in the 2020/2021 school years in a secondary school among pupils of the first grade of a four-year general secondary school. The youth group was the same age. Both girls and boys constituted the population. Pupils who selected teams themselves implemented the project. Pupils formed teams only within class groups. The group of pupils implementing the project dealt with elements of the project method in their primary school education. The knowledge of working with the project method varied greatly between individuals. However, all the pupils have heard about this method and were able to define what it was. The project was carried out both in classroom and remote learning as a result of the Covid-19 pandemic.

The tool used to implement the project was the school educational platform used to conduct remote lessons. Pupils knew this tool and knew how to use it. The

classes that took part in the project implementation differed in terms of the level of chemistry implementation in secondary school - one class carried out chemistry at the advanced level, four class teams carried out chemistry at the elementary level. Two classes of the respondents realized biology at the advanced level, which is related to the greater number of issues in the field of biochemistry and organic chemistry learned by these classes. Entry-level chemistry classes had one hour of chemistry each week. An advanced level chemistry class had two hours of chemistry each week of school classes.

At the beginning of the school year, each class was informed by the chemistry teacher that they would be carrying out the selected topic this school year using the project method. The teacher asked each pupil to think about the difficulties they might encounter in their chemistry education. The pupils were asked to recall what skills developed in primary school chemistry lessons were a challenge for them. The first month of school education was intended to reflect on this issue. This part of the work is carried out while still in school. In the second month of schooling, the first lesson took place, where the issues related to the selection of the scope that pupils want to pay special attention to in the first grade during the project method.

Project implementation

Using the brainstorming method, the students tried to identify the skills that were the most difficult for them in primary school chemistry lessons. In each researched class, for a large group of pupils, it turned out that the problem was to correctly write and balance the chemical equations. The students mentioned various reasons for this situation. The students discussed which of the skills and activities is the most important in writing and balancing the equations of chemical reactions. (Bílek et al., 2018). The pupils' opinions were also divided. Some emphasized that the problem was to write the summary formula of a given chemical compound, e.g. the order of atoms or the number of individual atoms in a given chemical compound. Still, others said that sometimes they did not know what substances were created as a result of a given chemical reaction. Still, other pupils had trouble balancing the chemical equation correctly, even though they wrote the substrates and products correctly. On the other hand, pupils from all classes agreed that writing chemical equations is important and necessary in chemistry lessons. They also emphasized that their failures in the lessons of this subject were often related to incorrect writing of chemical equations. When asked about specific problems or a stage that made them difficult, they often said that they did not know and could not indicate such an element specifically (Kopek-Putała et al., 2016). When asked to try to draw a mind map showing the steps in writing chemical equations, they showed little enthusiasm for the task. They asked the question: Why should they draw such a structure? They showed discouragement. They proposed that the instruction could be created for writing and balancing chemical equations. They offered to write down in points specific thought operations to be performed. At the same time, they made a reservation that they prefer to prepare such instruction for elementary school pupils because chemistry issues were simpler there than they will be in a secondary school. The teacher encouraged the pupils to

formulate a specific problem that they wanted to solve during their project. Together, several proposals were identified, the most interesting of which for pupils was the attempt to determine how many "steps" are needed to write the correct chemical equation for primary school pupils. Pupils chose the topic: Stepping (Designing) the process of pupils' writing chemical equations for other pupils.

Purpose and hypothesis

On the basis of the topic chosen by the pupils, the aim of the research was determined: to make pupils aware of the complexity of the process of reconciling chemical equations as a necessary element of creating intrinsic motivation in pupils needed to involve them in their own learning process. The extension to the aspect related to internal motivation resulted from the teacher's observation related to the attitude to learning chemistry in the classes implementing the subject at the basic level. A hypothesis was also put forward: pupils are not aware of the complexity of the process of reconciling chemical equations, which results in discouragement rather than a constructive approach to this complex issue.

Students' work in the project

The pupils, together with the teacher, wondered what the stages of work on the project should be. Several versions of the tasks to be performed have been proposed. There were different suggestions in each class. Due to the transition to remote education at that time, it was decided to implement the project using a remote education platform because the pupils were otherwise unable to cooperate and implement the project. As the first stage of implementation, a questionnaire was defined, which was to serve as a pretest. This survey asked questions about pupils' perceptions of writing chemical equations. They were also intended to summarize the initial preparatory activities for the project. The situation related to remote education made pupils need to describe their emotions as well as the need to express their opinions, which was reflected in the formulated questions:

1. Learning to write chemical equations was for me in primary school (results presented in this article - Fig. 1, Tab. 1).
2. How many mental operations does the pupil have to perform to write the chemical reaction equation correctly? (results presented in this article - Fig. 2, Tab. 1).
3. What skills should a pupil have to write a correct chemical reaction equation?
4. Do you find writing chemical equations difficult for other pupils?
5. What can make it easier for a pupil to master this skill?

The second task listed in the project was the part in which each pupil, based on his or her own knowledge and skills, had to write down a proposed instruction that would allow an elementary school pupil to write a correct chemical reaction equation. The teacher proposed to use the Ishikawa diagram for the cause-effect analysis of the problem (Cieśla et al., 2018).

The pupils were skeptical about this idea. They stated that they knew little about this tool and were afraid that it might hinder their task. At the same time, there was a group of pupils who became interested in the idea. A solution was found that the pupils could, but did not have to, use the diagram to implement the project. It was

also agreed that the diagram would appear in the second stage of work on the project but as an alternative for each pupil. In addition to the diagram, it will be possible to write instructions in points. The teacher emphasized that any person who would like to broaden their knowledge on the use of the Ishikawa diagram for the cause-and-effect analysis of the problem that arose will be able to contact the teacher through the platform and get help.

The next planned stage was to be a snowball method and teamwork. Pupils were supposed to form teams. It was agreed that there would be no imposition of who is to work with whom; the pupils will choose themselves into groups. The task of each formed team was to compile individual concepts of instructions for primary school pupils, compare them and select common elements that appeared in each pupil in a given team. Then, the end result of the work was to be a joint instruction. At this stage, pupils were also to summarize their commitment to the project.

As in the planned second stage, each team had the option of using the Ishikawa diagram or structuring the final instruction in points. The final stage was the post-test as an individual questionnaire that allows pupils to verify what they have learned while working with the project method and how, after its implementation, they perceive the complexity of the process of writing chemical equations. At this stage, the pupils determined that two weeks would be sufficient to complete each planned stage. They decided that such a time regime would mean that they would not postpone the implementation of the project, because thanks to the preliminary activities, they already have some thoughtful elements. They found that using a remote learning platform would help them complete the teams work stage faster because it will be easier for them to arrange a joint meeting. They emphasized that it would be easier to consult the teacher, which would also improve the work process.

The problem turned out to be that only teachers could publish links to surveys on the platform in the task module. It was agreed that the teacher would introduce the questionnaires to the platform, constructed on the basis of common findings as a result of the discussion and made them available to pupils in the tasks module with an assigned time schedule. This is due to the teacher's channel owner's rights. As team members, pupils can only refer certain items to the teacher. These technical problems were solved and the sending of the work by individual pupils and entire teams went quite smoothly. It was important in teamwork to establish a team leader who contacted the teacher and supervised the implementation of tasks assigned to individual members of his group.

It should be emphasized that despite the limited direct contact between the teacher - pupil and pupil - pupil, thanks to good planning and discussion of the schedule of activities, the works on the project ran smoothly in most groups. Pupils showed diligence and boldly asked questions if they encountered a problem. The problem that arose when pupils were matched into teams was that four people did not have their own groups. This concerned 4 people out of 121 starting work on the project. They wrote to the teacher who encouraged them to tell other people in the class about their problem, which helped them, join the less numerous groups. The use of the platform for distance learning greatly facilitated the flow of information and allowed to improve work.

The problems that arose during the implementation of the planned activities related to technical aspects. Whether a given stage has been properly documented in the cloud, where work progress has been recorded. Occasionally there were problems with understanding the pre-test and post-test questions. They concerned only pupils who were absent for independent reasons during the joint planning and set of activities.

The pupils had a problem using the Ishikawa diagram (Cieśla et al., 2018) and more often chose to create instructions for writing chemical equations using a list in points. Due to distance education and the state of the pandemic, pupils could not present the results of their project to pupils of another primary school to whom the instructions were dedicated. This is due to the incompatibility of e-learning platforms between schools.

At the end of the project, it was agreed that the results of the work of individual groups are discussed within the classroom. However, if the pandemic situation allows and stationary work at school becomes possible, instructions will be presented to primary school pupils to verify their suitability.

Results

The end results of the work of each team from individual classes were ready-made instructions in the form of text files that can be used to present the discussed issue to primary school pupils. During the discussion summarizing the project, students noted that when writing the instructions, they were more focused than when their task was to write and balance a specific reaction equation. They found that focusing on finding the next step to take made this task easier for them. Whereas, in writing and balancing a specific equation, reactions get discouraged whenever they encounter any difficulty.

An unexpected effect was that some of the instructions created by individuals in the first phase were longer and more detailed than the final, team instructions. It seems that the students who were more diligent and interested in the subject did their job accurately. Later, as a result of working in groups (with the snowball method), the less diligent and less involved students simplified the procedures.

The last element of the work was a summary by the pupils of what they had learned during the project. In this dimension, two groups of pupils were distinguished. One group emphasized that they liked working with the project method. It is interesting for them. It allowed them to repeat the necessary steps needed to write and balance the correct equation for the chemical reaction. They assessed such repetition at the beginning of chemical education in a secondary school as a good investment, which will pay off in the future in learning this subject. Their statements were dominated by the fact that the implementation of this project increased their social competencies regarding cooperation with others. An example of a student's comment: *I learned how to solve the equations of chemical reactions and I got to know the people with whom I worked.* Another interesting summary of the student: *As a result of the project, first of all, I learned how to cooperate with others, share responsibilities for individual people and motivate others to work. I also started to perceive chemistry much more interestingly - not only as a difficult school subject but also a very interesting and full of secret science*. It should be emphasized that the project was implemented in the first

grade and the pupils of this year were only 1.5 months together in the school. From mid-October, they implement their compulsory education in the form of remote learning. This situation results in a great need for social contacts and the opportunity to get to know other people from the class. Working using the project method allowed them to meet other people in the class despite remote education, and most of the pupils paid attention to it. They also liked that they rose to the challenge, especially if they carry out entry-level chemistry. They emphasized that the implementation of the project forced them to a conscious approach to writing chemical equations, which resulted in the systematization and consolidation of knowledge and skills from primary school. The attitude of the second, smaller group of students is disturbing. The project revealed their social problems, low motivation to work, and lack of self-confidence, boredom and lack of ambition. The answers of this group of students were short, for example: *I don't know*, *I'm bored with it*; *I don't feel like it*, *It's difficult for me to cooperate with others*.

Verification of hypotheses

In order to verify the hypothesis about the complexity of the process of establishing chemical equations, the following research questions were formulated:

1. How many steps does a student have to take to correctly write and balance a chemical reaction equation;

2. What opinion do students, who have completed primary school, have on this process?

Therefore, two pre- and post-test trials were distinguished, which contained the above-mentioned questions. The samples were tested against statistical hypotheses in which a homogeneous distribution of results was assumed (null hypothesis), against an alternative hypothesis with a heterogeneous distribution. The chi2 test was used for statistical analyses in Statistica StatSoft 13.1. The results are presented in the graphs of Figures 1 and 2 and in tab. 1.

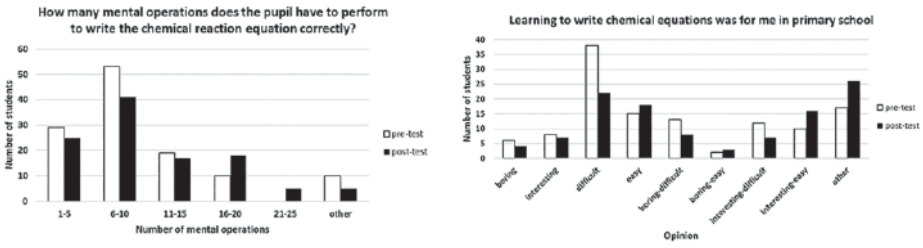

Fig. 1 and 2 Results of analyzed variables in pre- and posttest students' groups.

Tab. 1 The results of testing the hypothesis that the compared distributions are homogeneous in both samples pre- vs post-test. (Abbreviations: df -degrees of freedom, ML - maximum likelihood, *p* - test probability). Results were calculated by Statistica StatSoft 13.1.

variable	group	χ^2 ML	df	*p*	statistical conclusion
mental operations	pre-test vs post-test	12,461	5	0,029	distributions are not homogeneous
students' opinion about writing reaction equations	pre-test vs post-test	10,660	8	0,222	distributions are homogeneous

As we can see in Figure 1, the number of students who believe that in order to correctly write and balance a chemical reaction equation more than 16 to 25 steps have to be completed has increased. The number of students who thought it was only 1 to 10 steps decreased significantly. The group of students who find it difficult to write and balance chemical equations has also decreased significantly (Fig. 2).

Summary

The implemented project turned out to be a challenge for pupils. The project method changed students' imagination about the number of mental steps necessary to write chemical reactions' equations. They noticed that the process required more operations (Paśko & Haduch, 1999; 2000; Nodzyńska & Paśko, 2008, 2010) than they thought before. The students' opinion before and after the project was similar to the same. Fewer students answered that writing chemical reactions is difficult. Pupils who conscientiously and systematically pursued their goals achieved success and improved their competencies in chemistry as well as social competencies. It is worrying that there is a group of pupils who, despite the use of this activating method, remained passive and did not achieve satisfaction with the actions taken. This situation may result from both the difficulties in learning chemistry (Janiuk a Dymara, 2003, s. 1062; Rius-Alonso a Gonzalez Quesada, 2015), but at the same time it may be related to the economic and social situation experienced by pupils as a result of the Covid-19 pandemic. It should be emphasized that the application of the project method with particular attention to its proper implementation with care for the independence of pupils' work may be a source of satisfaction and motivation for pupils to learn. It is worth emphasizing that the external situation related to the Covid-19 pandemic may have an impact on the achieved results of pupils.

References

Bílek, M., Nodzyńska, M., Kopek-Putała, W., Zimak-Piekarczyk P. (2018). Balancing chemical equations using sandwich making computer simulation games as a supporting teaching method. *Problems of education in the 21st century,* 76(6), pp. 779–799.

Chałas, K. (2000). *Metoda projektów i jej egzemplifikacja w praktyce*. Wydawnictwo Nowa Era.

Cieśla, P., Nodzyńska, M., Baprowska, A., Bílek M. (2018). Implementation of Ishikawa diagram into project based education. *Project-based education in science education: empirical texts XV,* pp. 44–52.

Gołębniak, B.D. (2002). red. *Uczenie metodą projektów*, WSiP S.A.

Kopek-Putała, W., Nodzyńska, M. (2016). The implementation of the educational project "Feel the chemistry" in junior high school with students with learning difficulties. *Project-based education in science education XIII*, pp. 95–101.

Rusek, M., Dlabola, Z. (2013). What is and what is not a project? Rusek, M., Köhlerová V. (Eds.) *Projektové vyučování v chemii a souvisejících oborech* Charles University in Prague, Faculty of Education, pp. 14–19, WOS:000339813900002.

Paśko, J.R., Haduch, I., (1999). Trudności w uzgadnianiu współczynników reakcji chemicznych wśród uczniów szkół podstawowych. *Polska Chemia w Unii Europejskiej: VII Konferencja Dydaktyki Chemii, 4–8 Czerwca 1999, Kiekrz K. Poznania*. Poznań: Ośrodek Wydawnictw Naukowych, pp. 308–309.

Paśko, J.R., Haduch, I., (2000). Badania stopnia trudności wykonywanych operacji umysłowych na przykładzie równań reakcji otrzymywania soli. *Aktualne Problemy Edukacji Chemicznej*, Opole: Uniwersytet Opolski, Instytut Chemii, Zakład Dydaktyki Chemii, pp. 152–155.

Nodzyńska, M., Paśko, J.R., (2008). Badania stopnia trudności wykonywanych operacji umysłowych na przykładzie równań reakcji otrzymywania soli. *Current Trends In Chemical Curricula*, Praga, ISBN 978-80-86561-60-8, pp. 67-72.

Nodzyńska, M., Paśko, J.R., (2010). Automonitorowanie (przez uczniów) czynności umysłowych niezbędnych do uzgodnienia równania reakcji. *Chemické Rozhl'ady*, vol. 5, Bratislava ISSN 1335-8391, pp. 115–122

Janiuk, R.M., Dymara, J., (2003). Trudności w uczeniu się chemii w opinii uczniów. *Materiały XLVI Zjazdu Naukowego PTChem i SITPChem*. Lublin, 15-18.09.2003. p. 1062

Rius-Alonso, C.A., Gonzalez Quezada, Y., (2015). Teaching Chemistry To 2-3 Year -Old Children. (Eds.) Chova, L. G., Martinez, A. L., Torres, I. C., *Conference: 8th International Conference of Education, Research and Innovation (ICERI) Location: Seville*, SPAINDate: NOV 16-20, 2015 ICERI2015: *8TH INTERNATIONAL CONFERENCE OF EDUCATION, RESEARCH AND INNOVATION Book Series: ICERI Proceedings,* pp. 7441-7448.

https://www.statsoft.pl/zasoby/do-pobrania/wersja-probna-statistica/

Stepping (Designing) the process of pupils' writing chemical reactions' equations for other pupils

Abstract

The main goal of the project was to make students of the 1st grade of high school aware of the complexity of the process of writing and balancing chemical equations. The use of various teaching methods (project method, brainstorming, snowball, Ishikawa diagram) was aimed at creating in students the intrinsic motivation that is needed to support their own learning process. It is hypothesized that students are unaware of the complexities of writing and balancing chemical equations. Lack of this awareness causes students to struggle with this issue, which results in their discouragement. As a result of the project, students prepared instructions that gradually described what steps should be taken to write and balance a given chemical reaction equation. As a result of working on the project, students realized what

are the next steps in writing and balancing chemical equations. The attitude of students has changed - fewer students think that this issue is difficult.

Keywords: project method; remote learning; writing and balancing chemical reactions' equations

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