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Using Project Based Learning in the „Thermochemistry" Topic – example from education practice

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Abstract: *The selection of suitable approaches, methods and technologies in education is of crucial importance for achieving the goals of the educational process. The introduction in pedagogical technologies of elements from research activity enables the teacher not only, and not so much, to educate but mostly to help the student to learn, to direct his or her cognitive activity. One of the most widely spread contemporary types of research activities of students is project activity, which is implemented in the course of project learning.*

The aim of the present report is to present our experience for the implementation of project based learning with 11 grade students at the „Dr. P. Beron" Secondary School of Mathematics in the studying of the „Thermochemistry" topic. The students use the student's book published by Regalia, with educational content for 10 grade.

Keywords: *project based learning, thermochemistry*

Introduction

If we try to imagine how the ideal owner of a secondary school graduation diploma looks like, then the following profile would emerge: responsible, quick-witted, consistent and critical, thinking, knowing how to study, to work well with the others, communicative, able to solve problems, to manage his or her time, and able to lead things to the end. How can we fit natural sciences and more specifically chemistry into the forming of the profile of the ideal graduating student? We are all well aware of the situation: in Bulgarian school's natural sciences are becoming less and less popular, and the opinion prevails that the state education requirements and educational curricula overload young people in terms of information and repel them from science. The findings of international studies in the field of natural sciences and mathematics are not more hopeful.

Similar difficulties in natural sciences education are mentioned by a number of authors. Gilbert points out three increasingly deepening problems in school education in natural sciences.He relates the

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first problem to the increasing intellectual isolation of natural sciences, compared to other school subjects. They are frequently taught as a combination of predetermined truths, and there is no possibility for discussion on them. As a result, students do not feel them as their own ideas. The second problem is the problem of how to adapt natural sciences learning to the preparation of students for being future citizens, since it is traditionally aimed at preparing future specialists – scientists and engineers. There is an essential difference between the two cases, mostly in what is taught, how it is taught, and why it is taught. Gilbert sees the third problem in the increasing discrepancy between the set of problems of contemporary science and the content of natural sciences learning. The educational content is becoming more and more dated, and it is diverging from contemporary scientific problems. According to him, „whereas natural sciences shape the face of the contemporary world, learning in natural sciences seems to be engaged in the challenges of yesterday“ [5].

At the same time, the principles to which school education is subjected, according to the Pre-School and School Education Act, are directed towards the interest of students, towards the quality of education and the innovative nature in pedagogical practices [10]. The Law also stipulates the key competences that have to be formed in students in the course of education in the respective degree.

The generalized conclusions from the polls conducted by us indicate the wish of students for more dialogues and more active participation of them in all stages of the process of learning. Our experience shows that this can be obtained by using active or interactive methods of learning. One of these methods is the project method, implemented in the practice of project based learning. In the last few years, that learning has been turning into an inseparable part of school practice in all school subjects, including chemistry and preservation of the environment.

The aim of the present report is to present our attempt to implement project based learning with the students of 11 grade at the „Dr. P. Beron” Secondary School of Mathematics in Varna, in the studying of the „Thermochemistry” topic. The students are taught on the basis of the student's book published by Regalia, with educational content for 10 grade.

Theoretical substantiation

The projects method was proposed for the first time by J. Dewey and was developed by W. Kilpatrick. His main idea was "learning through action". J. Dewey determines the project in pedagogy as a “method of thinking experience". “The basis of a particular project is always live participation in the live reality, and in the course of that, with common efforts, one or several solutions are obtained regarding a particular problem, and they finally merge into one product, into a specific result" [4, 6].

According to V. Dimitrova and S. Manev, a students’ project can be determined as a relatively independent elaboration by students, as a consequence of which results are obtained and conclusions are formulated" [2].

The nature of projects is determined by the specifics of educational content, the age peculiarities of students, and the scope of its themes. In projects, in a fair manner, teachers and students work on a real problem. In the method of projects, the process of education provides conditions for students to create products on their own and to gain experience in creative research activities.

The contemporary model of project based learning was developed by the Buck Education Institute, USA, in the end of the 90s of the 20th century, in response to the efforts for school reforms. Project based learning is defined as "an instructive method which presents students with complicated tasks based on challenging questions or problems, which include problem solving, decision taking, research abilities, as well as self reflexion, which include facilitation by the teacher, but not provision of direction [7, 9]. Project based learning is one of the most effective ways of obtaining the goals of contemporary education. Placing the student in an active, creative position, it enables the enhancement of motivation and the mastering of lasting knowledge, skills and competences.

Results

The school curriculum in chemistry and preservation of the environment for 10th grade includes compulsory educational content related to the studying of chemical processes. One of the directions of discussing them are heat effects of chemical reactions included in the „Thermochemistry” topic. The topic presents ample opportunities for project based learning. Proceeding from that, in the preliminary distribution four school lessons are allotted for the studying [3].

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In the frames of the first lesson, the building of an intellectual map of the notion starts. The map illustrates the areas with which student's associate thermochemistry, and determines the directions in which they will have to implement a deeper study, namely: foods, fuels, chemical relations, luminescent organisms in nature, animals with specific behavior due to thermochemical processes. Students get acquainted with the topic and the aim of the project, and they are divided into groups in a natural way: they select to work in the area they are interested in. The deadline for the study is appointed, the necessary instructions are given, as well as the requirements for the generalization and presentation of the materials. In that manner, the first (starting) phase of the project is implemented [1].

In the course of the study and the processing of the information, the teacher provides consultations and guides the groups, after which the ready product is uploaded into virtual space – google classroom. In that manner, each student from the class has access to the entire information collected. After the different areas have been studied, the need emerges for the updating of the intellectual map. That is carried out during the second lesson, in which, by the method of ideas generation, brainstorming, the most suitable topic for the generalizing lesson entitled „Energy: known and unknown" is determined. The students are provided with a key code by means of which they gain access to the information uploaded into the google classroom. The second phase of the project is implemented.

The third phase, the culmination, is implemented in the course of the third lesson. It is held in the presence of two teachers, the chemistry teacher and the biology teacher. The work during the lesson is again organized in groups, but the groups are formed at the start of the lesson. The classroom is equipped with furniture that enables the modular arrangement in a circle, and the space is organized in five sectors. Each student draws a card on which there is a symbol determining his belonging to one of the groups, and goes to his or her place. Each of the individual sectors is marked by a symbol showing the topic on which the group is going to work, there is a folder with material on the topic, and a card with a key code for unlocking the data base containing information collected during the second stage of the project activity.

Group One works on the „Foods" topic. The task is the following: In your folder you will find two materials: a link https://zdravoslovno.maxamuss.com/which will provide you with access to a site dedicated to a project, „The Bulgarian nation is sick", and a data base entitled „Calories content of foods". Both products have been developed by your classmates. Get acquainted with the capabilities of the site. Study the information located on the site and in the data base. Search for additional information on the categories into which people are divided, according to their daily need for calories. Using the information collected, and the materials about the calorific content of foods located in the data base, determine with the aid of the calculator the daily need for calories of two of your classmates, differing in sex and in physical activity. Prepare a daily menu for them.

Offer a form of popularizing the menu prepared by you among the students from the school!

Group Two works on the „Fuels" topic. The task given to them is the following: We are on the threshold of the new heating season. The publishing is forthcoming of a public order for the choice of fuel for the winter period. The school principal is turning to the chairman of the social council with a request for the conduct of a preliminary study and the invitation of companies which will present their offers. If you are a representative of a company carrying out deliveries of a specific type of fuel, which arguments would you use to convince the school principal that the fuel you are offering is the most suitable one for the forthcoming heating season?

Group Three works on the „Light Energy" topic. The participants get the task for work in the form of a worksheet with the following content:

WORKSHEET

Light Energy

Name……No.…… Grade…….

TASK 1. Read the text and answer the questions following it:

„One night I was travelling by train from Florence to Rome. Suddenly my attention was attracted by sparks flying past the carriage. At first one would think these sparks came from the engine funnel. When I looked through the window, I saw that our train was speeding through a light, transparent cloud consisting of tinygolden-blue flames. They were sparkling all over. They rotated, they cut through the air as rainbows

of light, in different directions, crossed each other, sank and emerged again in the night mist, sprinkling the ground as if with a rain of fire. That fantastic spectacle lasted for five minutes, and maybe more. Then we came out of the cloud of the lighted particles, and left them far behind." From the notes of Prof. V. Lunkevich

1/ What did the professor observe?.....

2/ Describe what the reason for the lighting was? .....

3/ Express the mechanism of lighting by means of a chemical equation ……

4/ Search for information for other sources of "live light" in nature……

TASK 2. Describe the model from nature that scientists used to create LED lighting.

TASK 3. Study artificial sources of light. Clarify the principle of operation, advantages and disadvantages of each of them. What lighting fixtures would you prefer to use in your homes?

The tasks for Group Four are also given with the aid of a worksheet.

WORKSHEET

Bombardier Beetle

Name……No.……Grade……..

Your task is to work with a text. Enter the google classroom, using the password or …. In the „Bombardier" folder you will find the complete text of the information on one of the strangest creatures in nature. Get acquainted with the information on the bombardier beetle, and proceed to the implementation of the tasks given.

1. Present the chemical processes during which the gas mixture of the bombardier beetle is formed, by means of thermochemical equations.
2. Calculate the heat effect of the chemical processes going on in the reactor of the bombardier beetle.
3. Having in mind that 1cal= 4,18 J, and 1 kcal= 1000 cal, present the result of *m.2*in jouls.
4. What is the heat effect of the process?.....
5. Calculate the heat effect for 1mol hydroquinone.
6. What is the amount of the hydrogen peroxide that reacted, and what amount which did not react remained?
7. Using Figure 1, note:
   a. the parts of the arrangement of the bombardier beetle's chemical weapon;
   b. where the hydrogen peroxide and hydroquinone which are secreted by the acini form gland are stored.
8. Point out the role of the *catalase* enzyme and the biochemical nature of processes of the bombardier beetle……
9. Explain the possibility for a biochemical reaction at 100º degrees in the bombardier beetle.....
10. How do the skin spots burned by nitric acid look?

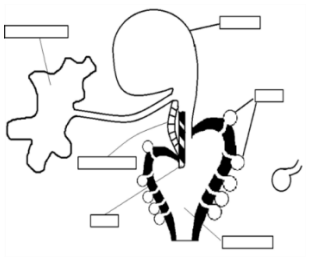

Figure 1. Arrangement of a bombardier beetle

The worksheet for Group Five includes an experimental task and tasks related to the calculation of heat effects.

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WORKSHEET

Experimental and logical tasks

Name…… No.…… Grade…….

Task 1. Measure the heat effect of the solution of hard sodium hydroxide in water.

Preliminary preparation and conditions assumed:

The flask is used both as a reactor and as a calorie meter for measuring the amount of heat absorbed or emitted. It is assumed that the heat effect is manifested only in the change of temperature of the water solution and the glass of the vessel. The loss of energy into the environment is neglected. The increase in temperature by 1°C is related to the absorption or the emission of 1 calorie of heat (cal). 1 cal = 4,18 J of heat.

Necessary aids, materials and chemicals: crystals of **NaOH**, water, erlenmeyer flask with a capacity of 250 ml, thermometer, glass stick, plastic spoon, electronic scale, magnetic stirrer, filter paper.

Safety rules: When working with a solution of sodium hydroxide, protective gloves have to be used.

Method of work:

Dissolve 2 g **NaOH** in 200 ml of water and measure the temperature, before and after the dissolution of **NaOH**.

Sequence of the operations performed:

1. Weigh 2 g **NaOH**;
2. Weigh the erlenmeyer flask……;
3. Pour 200ml of water into the flask;
4. Measure the temperature of the water. Stir the water in the flask continuously, until a constant temperature is reached;
5. Mark the temperature measured in figure 1, flask 1;
6. Add the 2g of solid **NaOH;**
7. Stir using a magnetic stirrer, until all the crystals have become dissolved;
8. Measure the temperature again (fig. 2);
9. Mark the temperature measured in fig. 2, flask 2;

Attention! Never dispose of waste chemicals into the sewer drain! Transfer the waste solutions into the becher cup prepared for the purpose. Wash the vessels under running water. Clean your workspace.

NaOH (solid) + H_2O (liquid) NaOH (solution)

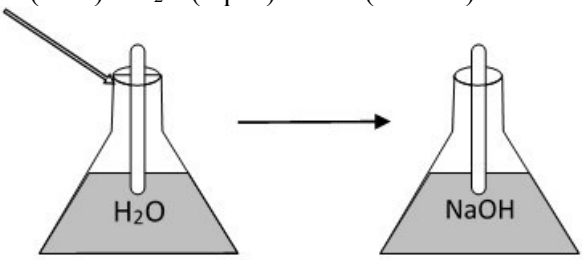

Figure2. Measure the heat of dissolution of sodium hydroxide

10. Perform the calculations:

a) calculate the change in temperature:

$\Delta t^o = t_2^o - t_1^o$

t_1^o–temperature of **H_2O**prior to the test;

t_2^o–temperature of the solution of **NaOH**.

b) calculate the amount of heat released, **Q_x**, in **cal**, if you know that the change in temperature by 1°Crequires 1.0 cal for water and 0.2 cal for glass with a mass of 100 g.

Δt^oC . 1 cal. 200 g = Q_1

Δt^oC .0,2cal. 100 g = Q_2

$Q_x = Q_1 + Q_2$

c) calculate the number of mols of **NaOH** by the formula:

d) calculate Qfor dissolving 1 mol of **NaOH**:

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e) convert calinto kJ, if you know that 1 cal = 4.18 J.

11. Represent graphically the heat effect of the process.

Task 2. Using the information from the log available in the google classroom regarding the tracing of composting implemented in the secondary school's yard in the years 2015 and 2016, plot a graphic reflecting the change in temperature for the first eight consecutive measurements in 2015 and 2016. Determine the heat effect of the process.

Task 3. In their strife for inventing a perpetual motion machine: „perpetuum mobile", experimenters with scant scientific and general knowledge have proposed a variant of such a machine. In virtual space, google classroom, the four stages of operation of a perpetual motion machine are represented. Transport yourself into the past and describe the operation of the machine.

What are the inventors' mistakes? Does a perpetual motion machine exist?

The work on the tasks continues throughout the lesson and finishes with the development of the final variant of the product. In the course of the joint activities in the groups, students develop tolerance, independence, creativity, proactivity, as well as skills of working in a team.

The final stage of the project activity, the presentation and discussion of the results, is carried out in the last lesson. One representative of each group presents the results of the group activity before their classmates. The entire group participates in the discussion. The aim is to acquaint all the students with the information obtained and with the solutions of the tasks posed.

At the end of the lesson, reflection on the activity performed is carried out. The participants in each group have to answer the following questions: What did you expect to learn in the course of the work on this project? Why did you choose this way of solving the task posed? What posed difficulties in the course of the work? What omissions in your knowledge did you discover? Are you satisfied with the results obtained? What did you learn about yourself in the course of the work?

Replying to the questions, students learn to analyze their own achievements in learning, to adequately assess their actions, to freely express their opinion.

Conclusion

Project learning is one of the opportunities by means of which we can turn the school into a territory attractive for students. The participation in projects expands the knowledge of the students taught in the specific project topic, and furthermore, it develops important key competences on which the successful professional development of the individual person is based. A prerequisite for that is team work, in the course of which students learn to express their arguments, to substantiate their position, and also to be tolerant, cooperative, creative, communicative. And also perhaps get closer to the profile of the ideal holder of a secondary school graduation diploma.

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