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Application of the project method in physics education in classes with intensive studying of English

G. Malchev*

Peyo Kracholov Yavorov Profiled High School, Petrich, Bulgaria

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The article is dedicated to project-based learning as a way to create an interactive educational environment that stimulates students' cognitive activity. It dwells on the essence of the project method and the preliminary stages the preparation of a training project goes through. Emphasis is placed on the application of this method in physics education. The article also presents an option, a feasible one in common pedagogical practice, of including project-based physics education in the school curriculum of 9th graders with intensive study of English in junior high.

Keywords: physics education, project method, English language, information technology, interdisciplinary relations

INTRODUCTION

Contemporary pedagogical reality has made physics education a real challenge bearing in mind the diminished interest on the part of students in this academic subject. The latter often consider physics hard to learn because it requires much greater effort and logical thinking to understand the various processes and phenomena that are studied at school. However, in the course of achieving a goal even the hardest obstacles can easily be overcome at a certain point provided the right approach has been found. In this particular case this means selecting and combining different methods and means aiming at boosting students' cognitive capabilities and motivation to study. In and out of school, ways should be found to inspire students to become explorers and obtain knowledge on their own through various activities. There is no doubt, far more efficient a form of education is for students not just to study and re-produce what they have learned but to think, come up with ideas, discuss issues, review and summarize solutions to pressing problems of science, technics, nature, outer space. The analytical perception of the physical matter is definitely a way to bring science closer to students so that they can understand it better. That is why contemporary teachers should not just teach and make students learn what they have been taught, they need to trigger students' thinking through intellectual interaction. Such interactive ambience relying on a multitude of methods and the application of various approaches can be founded on project-based education. Pedagogical practice has shown that using projects in physics education has universal appeal among students. Project work makes students braver and more confident in their studies. Besides, they come up with creative ideas and ways of implementing them. Thus they come to realize physics is not that hard a subject to master.

THE ESSENCE OF THE PROJECT METHOD

The project method is not entirely new – it first appeared at the beginning of the 20th century in the USA. It is also known as 'the problem method' and was initiated by John Dewy and his student William Killpatrick who made use of the ideas of the humanistic stream of philosophy and pedagogy. The method was pretty successful and was introduced to American schools due to its rational combination of theoretical knowledge and its practical application for the solution of particular everyday problems. During the first decade of the last century it got the attention of some Russian pedagogues but it was not until the 30s that it became common practice in the ex-USSR [1].

"All that I learn I know what I need for and where and how I will be using it" – this somehow summarizes what the project is all about in contemporary context.

The term 'project' is what project-based education is really based on. Translated literally from Latin it means 'thrown forward'. It is often used in different fields of human life denoting a plan, an intention. Didactics views it as a "topic for research (survey) in the context of the didactic tasks (without opposing it to or eliminating the subject curriculum requirements), the successful development of which presupposes both theoretical background and practical implementation" [2]. An activity the content of which is document-certified leading to the accomplishment of set goals over a certain period of time' is yet another definition in terms of the activity approach.

* To whom all correspondence should be sent:
E-mail: gmalchev@abv.bg

Participation in project work promotes students' thinking for themselves and thinking creatively, finding and solving problems. That is usually achieved by integrating knowledge from different scientific fields, which in its turn leads to the development of certain skills like foreseeing the results and possible consequences of the decisions students have made [3]. Central to the realization of the project method is students' work – individual, pair or group work, which aims at solving a problem. The result of their activity – the final material product should be presented in public in due form. Thus the school project is an all-round cognitive activity comprised of a goal, topic, planned activities and results.

Work on the project starts with defining unambiguously the topic [4]. Then it is open for discussion among the participants who work out the details and plan the activities. The planning can be done within the school or it may involve the coordinated efforts of several schools. The teacher should emphasize certain parts of the project work so that the students can gradually get a full grasp of it. Initially the teacher should act the part of a leader. Then, as the working process progresses and should any obstacles appear he/she should be a consultant, a mentor figure [5]. The more aware of the imperatives and the final results the students are, the greater their interest. In fact, project work at school is quite a challenge for students to demonstrate their personal qualities and skills.

Working out the school project goes through the following stages [6]:

Stage 1. *Research* – that involves selection of the topic, brief analysis of the problem, formulating a hypothesis, discussion of the research methods to use, forming groups and giving them assignments.

Stage 2. *Analysis* – it has to do with analysis of the available information and searching for up-to-date approaches to accomplish the goal of the project, as well as working out a plan of the activities.

Stage 3. *Realization* of the planned activities.

Stage 4. *Presentation* – reviewing and presenting the results.

Stage 5. *Control* – analysis of the results and assessing the fortes and weaknesses of the project.

Project-based learning goes far beyond the limitations of the authoritarian and reproductive methods. It entails a self-centred, interactive and brilliantly concocted mixture of methods and means. It also provides the chance for the teacher to take the students' strengths into consideration and act upon them. That, in its turn, stimulates and updates the already accumulated knowledge and skills, which is the perfect foundation for future individual cognitive work.

PROJECT-BASED EDUCATION IN PHYSICS

The project method combined with the traditional lesson planning in physics classes adds to and enriches the teaching process thus making it interesting and innovative. Such an addition follows the trend in worldwide educational theory and practice of re-locating the functions and individual work of the students in class. That makes education more personal and makes the most of the students' skills acquired in various fields of science.

In general, for students to be able to gain good and long-lasting knowledge of physics, we should bear in mind two important factors:

- *the way the teacher schedules and works out the content of the coursebook;*
- *the character of the cognitive activity performed by the students.*

These factors determine to a large extent the level of mastering the forms of logical reasoning like analysis, synthesis, comparison, systematization, abstraction, review, providing specific examples. These factors are of crucial importance in project-based education. Without them knowledge acquisition would be impossible. The reason for that is simply because knowledge should first be understood and then acquired. Then again understanding depends on the way scientific information is perceived by the students and the level of formation of the abovementioned logical operations [7].

By applying the project method students actually learn to develop expedient and diverse mental activity, which leads to easier and better acquisition of the complex concepts and phenomena of physics and provokes higher cognitive interest.

Practice and experience in the field has made it evident that the project method emphasizes the following [8, 9]:

- it promotes individual cognitive work during which the students solve problems they themselves consider important in the field of physics and its application in different spheres of life;
- the teacher gets in the shoes of an adviser and a partner who monitors students in the process of studying physics;
- there is constant teacher-student feedback, which helps in determining the fortes and weaknesses of the project activities, as well as in finding solutions to difficult issues;
- it entails a reflection on the personal cognitive activity of the students which is a sign of

self-governed development as concerns the synergic ideas of self-organizing in the complex nonlinear structures.

A PROPOSITION FOR PROJECT-BASED PHYSICS EDUCATION IN CLASSES WITH INTENSIVE STUDYING OF ENGLISH IN JUNIOR HIGH

The end of the autumn term of 2018/2019 marked the initiation of project-based learning in Peyo Yavorov Highschool in the 9th grade – a class profiled "Software and hardware science" with intensive learning of English. The topic of the project was "Heat Engines and the Environment" as was the title of one of the scheduled lessons for discussion in the 9th grade on the curriculum with students studying English intensively in junior high. Within a month three teams of students, two members each, were given the assignment to prepare three presentations of the project in Bulgarian, to translate them into English and present their papers in English on the day of the open-door lesson. For the purpose of the project task the students were expected to integrate knowledge and skills they had acquired in physics and astronomy, IT and English. In IT at that level of education making a presentation is considered the basics whereas the intensive learning of English in that particular class, especially in the 8th grade presupposes a good command of the language. That is why, the real challenge turned out to be the physics part, namely the teams' research work on the three topics: "The role of heat engines in the development of the technological revolution", "Heat engines and the pollution of the environment", "Ways of reducing the pollution of the environment". The first topic was assigned to Hristina Avramova and Andrey Manchev, Ilian Svechev and Ilian Karamfilov were given the second, the third went to Raya Pavlova, Theodora Chuchurova. Apart from that, the physics teacher Georgi Malchev prepared his own presentation for the open-door lesson dwelling on the description of heat engines and quotes from the students' work (Fig. 1). Another student – Antonina Borunsuzova was engaged to do simultaneous translation during the lesson. The selection of students was predetermined mainly by their fluency in English after a consultation with their English teacher Donika Dimitrova.

Fig. 1. The first slides of the presentations of the teacher and his students.

At the first meeting the students were given directions as to the goal of the project. They were specifically instructed to research the topic on their own and then to inform the rest of the class about the significance of heat engines in the development of the technological revolution and the harm they bring to the environment. The teacher consulted each team separately about the kind of information and photos their presentation should contain. He also highlit the stages the project was supposed to undergo in the course of the following four weeks as well as the deadlines they had to make:

Stage 1. *Searching the net for information* relevant to the three topics of presentation (deadline: two weeks for making the presentation, including consulting the teacher):

1. The role of heat engines in the development of the technological revolution:

- Historical background.
- James Watt and his contribution to the development of the steam engine.
- When did internal combustion engines first appear? What advantages do they have over steam engines?
- How do jet engines operate? Where can they be applied?

2. Heat engines and the pollution of the environment – one of the most pressing problems of our time:

- What are the reasons for the incomplete using up of thermal energy and its dispersion into the environment on the premises of thermo-electric and nuclear-power stations?
- How does water heating in water basins affect the organisms that live in them?
- What exactly is the 'greenhouse effect' that leads to warmer temperatures and climate change round the globe?

3. Ways of reducing the pollution of the environment and solving urgent ecological issues:

- What new engines are being developed to limit the pollution of the environment?
- Are there any advances in the usage of solar energy and its transformation into electricity?
- What new technologies are being developed for the reduction of thermal pollution?
- How does the installation of a centralized heating system prevent pollution?

Stage 2. *Handing in the presentations to the teacher of physics,* final proofreading, correction and editing the photos (deadline: the last day of Stage 1.) as well as *English translation* of the presentations and the lines of the teacher of physics intended for the open-door lesson (deadline: a week). Final consultations of the three teams were appointed with the teacher of physics and of the translator with the teacher of English. On the latter's advice some minor corrections were made in the English version of the text and plan of the lesson.

Stage 3. *Rehearsal of the presentations* in the presence of the teachers of physics and English (deadline: a week). There were two rehearsals altogether aiming at coordinating the work of the three teams and emphasizing the specific pronunciation of some complex English terms.

Stage 4. *Open-door lesson on the topic of the project.* The lesson was done in Bulgarian and English in front of the class and some formally invited visiting teachers (deadline: the last day of Stage 3.). At the beginning the teacher of physics delivered a brief lecture on the nature of heat engines and the three engine types – steam engine, internal combustion engine, jet engine. Every line on the part of the teacher was duly translated on the spot by the student in charge of translation (Fig. 2). After that the topics of the three teams were announced – one after another. In the same fashion the students made their presentations in English (Fig. 3). Then the teacher reviewed their performance and drew some conclusions about the effect of heat engines on the environment.

Stage 5. *Analyzing and evaluating the project by the teacher.* He commented on students' participation and gave them excellent marks for their diligence at the end of the lesson.

CONCLUSION

The realized school project managed to create specific educational environment, which made it easier for the students to learn about the ecological consequences of the work of heat engines. The project was based on their skills to research scientific information, analyze it, visualize and present it in the language they study intensively. The approach was rather different from the traditional one, but it definitely made the participants interested in similar linguistic presentations of other themes and topics of physics. That is way such presentations of three other topics in the next part of the coursebook were given to students as home assignments. It is obvious that the laws and phenomena of physics seem to impress students more when they think of them in terms of a foreign language.

Fig. 2. The participants in the project and their teacher of physics before and during the open-door lesson.

Fig. 3. Presentation in front of the class and some visiting teachers.

Combining physics with English and IT is definitely a working mechanism for establishing inter-subject relations. The project was carried out successfully because the students' learning of physics was supported by their linguistic and IT skills. This triple collaboration made them feel worthier, they viewed the project in highly positive terms and participated eagerly in all activities. Besides, they put a great deal of effort into their work demonstrating great responsibility, creativity and knack for research and exploration.

Over the last couple of years, project-based learning has triggered greater interest among students and teachers. One of the reasons is the contemporary trend of establishing a connection between theory and practice, education and production/scientific research. Another reason for the appeal of the method is the opportunity it gives

for the appointed tasks and activities to be performed online. This was of crucial importance last year considering the distant education schools had to switch to as a result of the global COVID-pandemic.

In general, project-based learning shows students the subject of physics in an entirely different light. Assuming the part of young researchers, they soon realize it is not just a theory but something accessible once they have reached the scientific truth through hard and active learning. This way they perceive more deeply and thoroughly the fundamental scientific explanation of the processes and phenomena in the whole material world. And that, as we all know, is the ultimate mission of every teacher of physics.

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