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Project-based learning: characteristic and the experiences with application in the science subjects

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Abstract

The project-based learning is a method for imparting students' and pupils' thinking competencies. First reference about project-based learning comes from the beginning of 20th century. Project-based elarning is described by many definitions. Every of these definitions contain solution of a problem by the group of students. By this method is different role of teacherr in comparison with traditional teaching. Teacher must be very good facilitator for the successfull implementation this method to the curriculum. During the seminars from Didactics of biology students had got an opportunity to try this kind of method. There were three groups of students, which presented three projects, where the main subject was biology. On the basis of presentation, there were determined some imperfections, which had got presented in the students projects.

Keywords: Definition of project-based learning; History of project-based learning; Project-based learning; Students

1. Introduction

The project-based learning belongs among method, which can to develop pupils thinking, to create original solutions, to develop cooperative work, to find available literary resources, to present finding information and to evaluate own findings. As it is seen, this method has got positive influence on the pupils or students, but it must be used during teaching. There is necessary to educate future teachers, because without quality base, we cannot await, using of project-based learning on the elementary or high schools.

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2. History of project-based learning

First reference to project-based learning was mentioned in the work of Kilpatrick (1918), who believed that using literacy in meaningful contexts provided a means for building background knowledge and for achieving personal growth. He suggested that projects be interdisciplinary math, science, social studies to provide learners with a rich array of concepts and ideas. He intended that topics come from students' interests, maintaining that group projects, proposed, planned, executed, and evaluated by students, would help learners develop an understanding of their lives while preparing to work within a democracy.

Project-based learning also reflects a Vygotskian perspective. Vygotsky theorizes that learning occurs through social interaction that encourages individuals to deal with the kind cognitive challenges that are just slightly above their current levels of ability [1]. He posits that concepts develop and understanding happens when individuals enter into discussion and meaningful interaction with more capable peers or teachers. These individuals can model problem solving, assist in finding solutions, monitor progress, and evaluate success [2].

2. 1. Definition of project-based learning

Project-based learning is described by many definitions. Every of these definitions contain solution of a problem by the group of students. And the work of students is commonly ended by the creation of some product, what can be thesis, report, design plan or model. Students activity takes a considerably length of time and there is a presence of variety of educational activities. And as Adderley et al. [3] provided teaching staff are involved in an advisory, rather than authoritarian, role at any or all of the stages – initiation, conduct and conclusion. According to Blumenfeld et al. [4], the essence of project-based learning is that a question or problem serves to organize and drive activities; and these activities culminate in a final product that addresses the driving question [4].

Project-based learning is an instructional method centered on the learner. Instead of using a rigid lesson plan that directs a learner down a specific path of learning outcomes or objectives, project-based learning allows in-depth investigation of a topic worth learning more about [5] . Through the construction of a personally-meaningful artifact, which may be a play, a multimedia presentation or a poem, learners represent what they've learned [6]; [7]. In addition, learners typically have more autonomy over what they learn, maintaining interest and motivating learners to take more responsibility for their learning [8]; [9]. Project-based learning and the construction of artifacts enable the expression of diversity in learners, such as interests, abilities and learning styles [10]. Project-based learning is a method for imparting thinking competencies and creating flexible learning environment [11]. Project-based learning has a nature of exploring new areas, discovering new scientific issues and integrating knowledge from different subjects [12].

The concept of project-based learning has a certain similarity with the notion of knowledge building [13]. These authors define ‘‘learning’’ as an activity that is directed to improve mental structures, whereas ‘‘knowledge building’’ is directed at improving knowledge objects such as explanations and models. Project-based learning can be described as involving both vertical learning (i.e., cumulating of subject matter knowledge) and horizontal learning (i.e., generic skills such as project management).

The main aim of project learning is an active connection of pupils to educational process. This process is characteristic of their openness. Problem situations and questions are created by teachers. These situations and questions caused thinking at pupils about topic. Project

scenarios are un-detailed and the final form is collaborative with pupils. The project realization is depended from pupils, from their creativity, fantasy, critical thinking, intrinsic motivation, interests and requirements. Teachers and pupils are inspired by their surroundings and by problems, which are creating by common life [14].

2. 2. Components of project-based learning

Kleijer, Kuiper, De Wit and Wouters-Koster [15] see four major characteristics of project learning: 1) self-responsibility for thinking and learning; 2) awareness of social responsibility; 3) thinking and acting from the scientific perspective but in a practical application; 4) relating both group process and product with professional practice.

Morgan [16] provided an interesting three general models of project work for educational purposes:

(1) Project exercise: The aim of this type of project is that students should apply knowledge and techniques already acquired to an academic issue in a subject area already familiar to them. This represents the most traditional kind of project-based learning. Project exercises are a part of teacher-centered project

(2) Project component: In this type of project work, the aims are broader and the scope is larger; the project is more interdisciplinary in nature and often related to ‘‘real world’’ issues; the objectives include developing problem-solving abilities and a capacity for independent work. Often, traditionally taught courses are studied in parallel with the project course.

(3) Project orientation: This term denotes the entire curriculum philosophy of a programme of study; the projects that students complete form the entire basis of their university education, while instructional teaching is provided only to supplement the requirements of the project topics. The subject material studied is determined by the demands of the project topics, which is in sharp contrast to model 1.

Project components and project orientation are the part of student-centered project.

Project-based learning contains some features. One of these is *problem orientation*, it is the idea that a problem or question serves to drive learning activities [17]. The second feature is a *constructing a concrete artifact*, which distinguishes project-based learning from problem-based learning. In project-based learning the process of constructing a concrete artifact (draft of a design or an end product) forces the student or student team to think through the steps of the construction process, and in some cases to execute them in an orderly fashion just like a construction team. The advantage over traditional studying is that gaps in knowledge cannot be easily overlooked or overcome by rote learning [17]. Tutorial feedback may be given either through a formal midcourse assessment or in the form of more informal continuous tutorial discussions between the teacher and the project group [18].The third feature of student projects is *learner control of the learning process*, which leaves scope for decisions regarding the pacing, sequencing and actual content of learning [19]. Learner control gives the students the opportunity to utilize their prior knowledge and experience ([17]). Other characteristic of the project method is its potential for using and creating multiple forms of representation. In modern working life most tasks require the combined use of (interdisciplinary) knowledge in different forms (e.g., abstract, concrete, pictorial, verbal, as formulae etc) [17]. The strength of the project method could lie in the fact that it enables not only the integration of knowledge from different disciplines but also theory and practice. In the process of project work, students can see and feel the reality to which difficult concepts and interactions are related [20].

Heitmann [21] differentiates between “project-oriented studies” and “project-organised curriculum”. Project-oriented study involves the use of small projects within individual courses, progressing to a final year project course. The projects will usually be combined with traditional teaching methods within the same course. They focus on the application, and possibly the integration of previously acquired knowledge. Projects may be carried out as individuals or in small groups. Project-organized curricula use projects as the structuring principle of the entire curriculum, with subject oriented courses eliminated or reduced to a minimum and related to a certain project. Students work in small groups with a project team of teachers who are advisers and consultants. Projects are undertaken throughout the length of the course and vary in duration from a few weeks up to a whole year.

Nowadays, the using of information and communication technologies is connected with project-based learning. ICT provide a rich learning environment and expose the learner to a variety of representations and configurations [11]; [22]; [23]. Barak, Waks & Doppelt [24] showed, the presence of ICT may enable the advancement of pupils in attaining higher academic achievement, and overcoming their cognitive and affective difficulties.

2. 3. Project-based learning and science subjects

Project-based learning is used in science subjects, of course, because designing projects that will be relevant and interesting for the students and giving them an opportunity to become independent learners are not the only arguments in favor of project-based learning incorporation into science teaching to non-science majors [25]. Authors mention here two additional reasons supporting their choice. The first one relates to the population of students participating in the physical science classes. The term "non-science majors" refers to a very heterogeneous group of students. In addition to majoring in different fields, and being freshmen, sophomores or juniors, these students have various science and mathematics backgrounds. Teaching such a heterogeneous class is a challenging task. However, if every one of these students is given an opportunity to make a unique contribution to the project in the field of his or her expertise, the class can benefit from such diversity. This opportunity might have an invaluable impact on students' content knowledge, as well as on their self-confidence and self-efficacy toward sciences [26].

The second reason relates to the learning environment in the project-based classes. PBI is based on the ideas of social constructivism, emphasizing the role of social environment in teaching and learning [27]. It promotes mutual respect, support and understanding, making an impact on student-student and student-instructor relationships. The role of these relationships in the science class for non-science majors cannot be overemphasized [24].

Other authors have had a view on the project-based learning, that the design principles of project-based leasing in science include a context that engages students in extended authentic investigations through a driving question, collaborative work that allows students to communicate their ideas, learning technologies to find and communicate solutions, and the creation of artifacts that demonstrate student understanding and serve as the basis for discussion, feedback, and revision [28]; [29]. A driving question links concepts and principles, and drives activities and investigations throughout a project. Projects extend student learning experiences beyond the classroom by posing driving questions that situate the science with issues that are likely to be of interest to scientists, community-based organizations, and families. Anchoring events provide students with common experiences that help them see the value and purpose of the driving question. Anchoring experiences also help

students relate to the new ideas explored in the project. Through teacher support, students design and perform various investigations to find solutions to the driving questions [30].

Successful integration of project-based learning into the teaching process is based on three dimensions [31]. First is ***practice-based nature of knowledge and learning***. It illuminates the relationship between knowledge, work practices, social groups and social context. The practice-based perspective makes a distinctive contribution by differentiating those forms of knowledge which are acquired individually and those which are acquired collectively [32]. Next dimension is ***project autonomy***. One important aspect of project autonomy is the extent of physical co-location among project members. Co-location has been identified as an important factor in knowledge integration among project team members [33]. In sum, such findings suggest that project autonomy is advantageous for learning by allowing the development of practices which are distinctively different to mainstream organizational practices. In effect then, one of the implications of project autonomy is to highlight the importance of a further division of practice — that between project practices and organizational practices — in shaping project-based learning [31]. The last dimension is called knowledge integration, what is identified in many studies as an important ingredient in innovation and learning [34]. It can be viewed as the synthesis of specialized knowledge into situation-specific systemic knowledge [35]. From a practice-based perspective, knowledge integration within a project involves overcoming barriers to the flow and transfer of knowledge arising from pre-existing divisions of practice among team members [31].

By the various types of project-based learning definitions, there is problem in many cases to distinguish between project-based learning a problem-based learning. A comparison of problem-based and project-based learning showed Perrenet, Bouhuijs & Smith [36]. The differences that they noted included:

Project tasks are closer to professional reality and therefore take a longer period of time than problem-based learning problems (which may extend over only a single session, a week or a few weeks).

Project work is more directed to the *application* of knowledge, whereas problem-based learning is more directed to the *acquisition* of knowledge.

Project-based learning is usually accompanied by subject courses (eg maths, physics etc. in engineering), whereas problem-based learning is not [37-42].

Management of time and resources by the students as well as task and role differentiation is very important in project-based learning.

Self-direction is stronger in project work, compared with problem-based learning, since the learning process is less directed by the problem.

3. Teacher’s role

The teacher's role is less that of an instructor who transmits information and organizes activities for practice and more that of a guide and a facilitator, it is a critical role, nevertheless. Projects require that teachers get to know their learners' interests. Teachers must listen for what has been called the teachable moment that point in a discussion when learners become excited about a topic, and start asking questions. Facilitating project-based learning requires the kind of leadership skills that allow teachers to help a group of learners to move in the direction that they want to go, pointing out potential pitfalls or making suggestions without getting defensive when students decide they like their own ideas better. It makes a difference if teachers possess a tolerance for ambiguity, some skill in helping learners negotiate conflicts, and enough self-confidence to not give up when a project peters out or

refuses to come together. Not all projects are successful. Some teachers are too inexperienced to guide the process well. They may expect too much ability on the part of the learners to take control of the project without having laid the necessary groundwork or they may fail to let students take the lead when they can. Learners do not necessarily take to project work wholeheartedly, either. Some may feel teachers are abdicating their roles if they do not provide answers, or they may not want to learn with and from their classmates [43-50].

There is still problem with low implementation with project-based learning into classrooms. Barron et al. [26] suggested inadequate material resources, little time to create new curricula, large class sizes, over-controlling administrative structures that prevented teachers from having the autonomy necessary to implement progressive approaches. However, the biggest problem does not lie on the school equipment, but on the undergraduate preparation of future teacher. If future teachers do not receive sufficient amount of theoretical and practical information, they will be not to practice project-based learning in their class.

4. Practical experiences

As it was mentioned above the important thing is to educate future teachers in the problematic of project-based learning. The project-based learning was the main theme during Didactics biology seminars at Faculty of Natural Science in Slovakia. First two seminars was theoretical, when the teacher and students discussed about project-based learning, advantages and disadvantages, what the project-based learning should contain. Teachers also provided information about, how to prepare a project. Totally 12 students were in the seminar group. Due to aim of seminar, students were divided into three groups. Every group contained 3 students. Students had got time to decide about main topic of their project. Last seminar was focused on the presentation of students' projects. Students had got an adequate amount of time to prepare project and its presentation. They had got a possibility to discuss with teacher, if the project is well prepared. Students were informed about basic points, which will be evaluated. When the projects were presented, the commission evaluated the presentation of students. The evaluation was anonymous. Evaluators were associate professors and professors from the faculty. They were from departments of biology, geography and chemistry. Evaluators obtained evaluation sheets, where they wrote points for every part/point of presentation. The minimum point for every part was 1 and maximum was 5. So, students could obtain 5 points minimally and 25 points maximally for their project.

The basic points were:

1. The level of project's interesting
2. Cross-disciplinary relations
3. The level of expertise
4. The succession of the project's parts.
5. The graphical layout

In the next part we introduce in briefly form every of three project. The names of projects are:

1. Mineral waters
2. Human races
3. Birds of Slovakia

The first presentation (***Mineral waters***) connected three subjects namely: 1. Biology – there were presented an influence of mineral waters on human body. 2. Geography – there were presented a distribution of mineral waters in Slovakia and 3. Chemistry – this part was the most presented in the presentation. Students were interested in chemical constitution of

mineral waters and on the basis of this they divided waters into the some groups. Next, they compared mineral waters according their composition of cat ions and anions. Net part was very interesting, because students showed their chemical experiments, which proved a presence or absence of the chemical elements in the selected mineral waters. Then students described chemical elements. Students were interested in their influence of human body. There were described these elements: calcium, potassium, sodium, magnesium and phosphorus. This project was evaluated very well. Only one small animadversion was toward graphical layout, but as it is mentioned above, the project was evaluated very well.

The second presentation was focused on the *Human races*. This one included only two subjects. One was biology, but this subject was introduced in the higher ratio in comparison with Geography, what was the second subject. In the first part students was focused on different definitions of races. The major part of presentation was focused on the description of white, yellow and black race. Into this part of presentation was included geographical information about the place of occurrence of these races. There were information about mixed race groups, but this information was very briefly. The last part of project was focused on the problematic of racism and then there was a short mention about laws in Slovakia, which are concerned to racism. This presentation was evaluated by evaluators by lower number of points. All points were little bit problematic except "The level of expertise", because level of expertise was very high. One evaluator had got problem with this, because it could be problem for other students.

Last project, which were presented during seminars were focused on the ***Birds of Slovakia***. However, the title of topic sounds interesting, students did not manage this project very well. There was only description of selected systematic groups of Slovakian birds. The order of groups was random, but as we know the order of systematic groups is appointed by specific rules. After this part, students presented selected endangered birds, but they were not able to say, why they chose these ones and not other. Last part of presentation was on the problematic of birds' flu. In this project was not observed any presence of second subject except of biology. The presentation of project affected on evaluators by boring effect. Every of evaluation points were problematic.

4. 1. Conclusion from projects presentation

Last seminar was focused on the discussion between teacher and students. Students presented own perception, they evaluated each other. They suggested improving of own presentation, said about mistakes. Teacher summarized own view and evaluation of evaluators.

From the pedagogical practice is important to know these findings:

- Students have got problems with cross-disciplinary subjects. There is dominating one subject (in this case it was biology) and other subject or subjects are represented only marginally. It can be observed, that information from other subject is added strained.
- Students have got problem with graphical layout. The presentation is too much colored and there is too many visual effects. Visual effects take away a attention from the main and important part of projects presentation. Other problem is with letters size, the frequent case is, that letters are too small. People, who are further from projection screen have got problem with reading.

There are too little resources. Students often use only electronic resources, but in the small amount. In some project were represented information from books, but information from

journals were totally missed. From the showed resources is obvious, students have got problem with foreign language. All resources were in native language.

- It was Slovak language).
- Some projects have got problem with expertise of their content. Sometimes, the expertise was in very low level and some it was in very high level. They were not to find the "middle way".
- Last problem is hard influenced. Some students saw only duty to make a project. There was not any interest about work on it. There is able to say, if these students will be teachers, they will not be use a project-based learning.

5. Conclusion

Project-based learning is relatively for a long time presented learning method, but it is still low using in the schools (elementary and high). This fact is maybe caused the low familiarizing with project-based learning on the college. There is the first problem, when the project-based learning is not represented in the faculties studying programs, there is hard to wait, that project-based learning will be represented in the high or elementary schools in the adequate form. Next problems are arising from the preparation of future teachers. Some of these problems are outlined above.

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