Project Activity in the Formation of Subject Competencies

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Abstract. The project-based learning has long established itself as one of the most stimulating methods of mastering the educational program. However, to study in depth of mathematical disciplines, project tasks must be specifically formulated for the topic being studied. The purpose of this work is to study the methodological relationship between the declared projects and the studied topic of mathematics, as well as a comparative analysis of the results of the development of three mathematical disciplines using the project method and without it. The work on the projects has been carried out for three years at our university and it is aimed at activating the independent cognitive activity of students. In 2018–2019, these were applied and educational projects, the topics for which were selected by teachers. In 2019–2020, students were given the right to independently choose a project topic based on their scientific interests and develop it. In one experimental group, students had the opportunity to consult with the teacher to find a solution to the project problem, in the other such an opportunity was not available. The results of both groups were roughly the same. The conclusion that we came to as a result of this work: project activity increases the horizons of students and allows us to see interdisciplinary connections. Project activity is more effective only if the student works closely with the teacher.

Keywords: Mathematics · Engineering education · The project-based learning

1 Introduction

In the current context, when the amount of knowledge necessary for a person increases sharply and rapidly, it is no longer enough just to assimilate a certain amount of knowledge. The ability to apply the acquired knowledge in various fields of activity becomes relevant [1]. In accordance with this, the role of the student in the educational process is also changing. He becomes an active participant in the educational process instead of a passive listener. One of the main goals of higher education is to teach students to independently supplement their knowledge, skills, and expand their capabilities [2]. This is confirmed by the current situation in education [3]. Unfortunately, the priorities in society and in science have changed recently, there is an increase in interest in the

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humanities, and interest in the exact sciences is falling. The content of mathematical education is disconnected from life. It's less emotional [4]. Since the course "Mathematics" in an engineering university is a basic disciplines, in this regard, there is a need to instill students ' interest in mathematics.

In order to increase students ' interest in mathematics and their cognitive activity, there are many methods and technologies of teaching: flipped classroom, project method, e-learning, interdisciplinary integration, etc. [5–8]. One of the most productive teaching methods is the project method. The project based learning method refers to interactive learning methods, and has long established itself as one of the most stimulating methods of mastering an educational program [9–11]. However, for a deep study of mathematical disciplines, project tasks must be specially formulated for the topic being studied [12]. Practice has shown that students try to solve problems with an open answer in any other way, but not by strict analytical methods. Moreover, the more complex the math course, the more difficult it is to formulate a project task that students can do. The purpose of this work is to study the methodological relationship between the declared projects and the studied topic of mathematics, as well as a comparative analysis of the results of the development of three mathematical disciplines using the project method and without it.

2 Problem Definition

Since 2018, Tomsk Polytechnic University has introduced a new system of training, which consists in the fact that students of all specialties and directions during the first two years, they study in the same curriculum and in the same disciplines. Examinations in general education subjects were abolished and differentiated credits were introduced. A student receives a grade on a differentiated credit when he / she receives a certain number of points from the rating system during the semester. Knowledge control is carried out during tests that take place in the middle and end of the semester for all students and control works that are conducted by teachers during the semester. All types of control measures are aimed at testing knowledge and practical skills. Thus, the verification and, as a result, the consolidation of knowledge of the theoretical material and the conceptual apparatus of mathematical terms does not occur. A paradox has arisen, which consists in the fact that the basic mathematical concepts, such as definite integrals, multiple integrals, differentials of functions, differential equations, etc. in the engineering university, they were not fixed by preparing for the exam. But the future engineer needs not only to be able to solve problems with these mathematical models, but also to understand what processes lead to them. To do this, you need to know the theoretical material very well, and this did not happen with the cancellation of the exams.

With such a system of training, after the first semester, it had become clear to the teachers of mathematics that students do not have a fixed theoretical material on the topics covered, which negatively affects further training, as well as the interest in studying mathematics and understanding the need to study it.

In order to maintain students 'interest in the study of mathematics and the formation of the conceptual apparatus of mathematics in the second and third semesters, studies were conducted on the impact of project activities on the learning of mathematics [10, 11, 13, 14] and on the formation of students' theoretical knowledge. In the second semester

of the academic year 2018–2019, the project method was implemented for students of 6 groups of different specialties. Work on projects was carried out in groups of 3 to 4 people. Students were offered a choice of two types of projects: applied (specific professional or subject problems were formulated and it was necessary to solve these problems using mathematical models and concepts studied in the second semester, namely, using multiples or surface integrals) and informational (independent proof of physical applications of multiple and surface integrals). Studies have shown that the project method has had a positive impact on student achievement [10].

In the 2019–2020 academic year, the study was continued, the purpose of which was to identify the impact of project activities on study of the course "Mathematics", which began in the 2nd semester of 2018–2019. There were two directions. The first of them was aimed at applying the project method for first-year students [11].

Work on the projects was also carried out in groups of 3 to 4 people. Students were offered a choice of two types of projects: applied and general education from the sections: linear algebra, vector algebra, analytical geometry, introduction to analysis, differential calculus of functions of one variable. The choice of the project type was the student's own decision. The general education project consisted in preparing an abstract on the chosen topic with mathematical examples. The applied project was divided into two types: in the first form, the student was offered tasks by the teacher, and the second type of applied project was that the student himself selected problems from electromechanics, which used mathematical models of the listed disciplines. The student was required to establish a correspondence between the content of the problem and the sections of mathematics studied in the current semester. Secondly, it was necessary to make a description of the problem in terms of the corresponding section of mathematics. Thirdly, students should independently learn the solution methods.

When performing all types of projects, the teacher worked closely with the students. There were consultations with the teacher at each stage of the task. There were the following activities under the project (Fig. 1):

1. Research papers;
2. Tasks proposed by the teacher;
3. Tasks proposed by students.

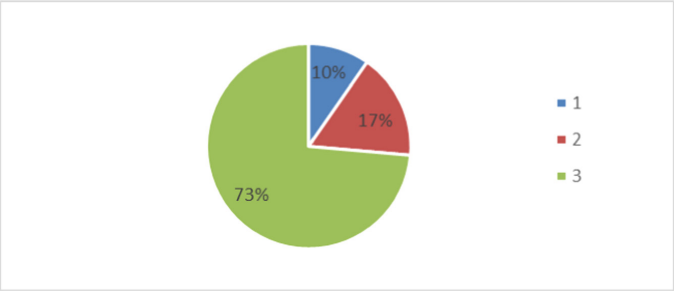

Fig. 1. Percentage of students' choice of project type

It should be noted that these students have retained their interest in project activities. Due to the epidemic in these groups in the 2nd and 3rd semesters, the project method was not applied. However, in the 4th semester, when studying Probability Theory and Mathematical Statistics, students were very enthusiastic about choosing professional tasks.

In the second direction, the study was conducted in 4 groups among those second-year students who had already participated in the project activity experiment. Two groups that did not work on projects in the 2nd semester were selected as experimental groups. The project was carried out by a group of students of 3 people. At the beginning of the third semester, students of all specialties study the topic of Differential equations in the Mathematics course. This topic is one of the basic ones for studying technical disciplines. Therefore, students were asked to choose the application projects, and the tasks that may arise in the professional activity of an engineer were suggested.

The first experimental group of students is studying in the specialty "engineering entrepreneurship". The scope of this group covers tasks with economic content. The second experimental group consists of students who study in the specialty "mechanical engineering". It should be noted that students who participated in the second semester in project activities, very highly appreciated the use of project-based learning. Students of another group majoring in mechanical engineering (who participated in project activities in the 2nd semester) independently decided to participate in project activities in the 3rd semester. The condition for them was as follows: independently, without the participation of a teacher, find and solve a problem whose mathematical model is described by differential equations.

Students majoring in engineering entrepreneurship treated project activities very responsibly. They independently analyzed the material, constantly consulted with the teacher on unclear issues, and showed the results of the study. The reports of these students turned out to be interesting and informative. They clearly answered the questions after the report, and were well versed in the material studied.

We would be happy to demonstrate example of such a project.

It was necessary to analyze the concepts of supply and demand, in which areas they arise, which demand and supply depends, to choose problems on the law of supply and demand, the mathematical model of which will be a differential equation and solve them. This task was proposed by a group of students.

Let the farmer sell fruit in the market for a certain (rather long) time, and he sell them after harvest, with weekly breaks. It is necessary to find a condition under which the balance between supply and demand would be maintained all the time.

The second experimental group (specialty mechanical engineering) was offered problems related to thermal conductivity. Students in this group did the project more independently. The teacher was approached only once when they were showing a presentation. Unfortunately, the reports of these students were not very interesting. It was noticeable that they did not understand the solution of the problems well and they could not answer the questions on the topic.

The results of the group of students who independently prepared the project were similar to the results of the second group. The students were able to select problems

from various sources (for welding production), the mathematical model of which is a differential equation, but they did not understand the solution of these problems well.

The conditions for working on projects remained the same. The work took place in a group of 3–4 people and at the end of the semester, all members of the group made presentations. The reports were evaluated by all students and teachers. Here are the results of the final assessment of the groups that reported the results of work on projects, which consisted of the teacher's assessment, the average assessment of classmates and self-assessment (Table 1).

Table 1. Evaluation results

Evaluation criteria	Average grade of students of the first semester	Average grade of students majoring in Engineering Entre-preneurship	Average grade of students majoring in Mechanical Engineering	Average grade of stu-dents majoring in Welding production
1	9.8	9.6	8	7.5
2	8.5	8.9	6.3	5
3	10	10	6	6.3
4	10	10	8.5	9
5	8.5	9	5	5
6	9	9	4	5.3
7	9.5	9.4	6.3	7.5

In the table, row 1 is compliance of the report content with the stated project topic; row 2 is ability to explain the scientific basis of the project and the independence of its implementation; row 3 is quality of the completed project; row 4 is quality of the visual materials; row 5 is using knowledge from other sciences and academic subjects; row 6 is answers to the questions and row 7 is elocution.

Among the second-year students there were both those who were already engaged in project activities, and those who were not engaged in it before.

- The second column of the table shows the results of the experimental group 1 (15 people), consisting of students who participated in project activities in the 2nd and 3rd semesters;
- The third column contains the results of the experimental group 2 (21 people), consisting of students who participated in project activities for the first time;
- The fourth column contains the results of experimental group 3 (14 people), consisting of students who participated in project activities for the first time, and performed it independently
- The fourth column contains the results of the control group 4 (15 people) consisting of students who participated in project activities in the 2nd semester, but did not participate in the first.

Students of all majors enrolled in 2018 took the "Comprehensive Exam based on the results of basic Engineering training" at the end of 2020. The comprehensive exam included questions in all the disciplines that students mastered during the two years of study: chemistry, physics, mathematics, law, and economics. This exam was rated at 100 points. The Math block was rated at 32 points.

At the same time, the tasks in the mathematics section were compiled in such a way that the ability to solve specific mathematical problems was not tested, but the ability to use the acquired knowledge in a comprehensive solution of the problem. It should be noted that the comprehensive exam was held six months after the end of the study of the discipline of Mathematics. The results of the comprehensive exam showed that if students do not study the discipline for a long time, then the residual knowledge of the students of the experimental and control groups is the same. This is due to the fact that the project activity was carried out on a specific topic in a semester and only in one, and in the complex exam there were 1–2 questions on all the studied topics for three semesters.

The analysis of the results of the comprehensive exam showed that the groups in which the project method was used at any stage of training showed the result in mathematics (6.7, 8.5 and 6.4), almost the same as the groups in which the project method was not used at all (6.65). However, in these groups, the average score for the entire comprehensive exam is higher than 69.3; 68.73 and 69.83 against 67.85 points of the group that did not participate in the project activity. In addition, we found that in those groups that used the project method of teaching, the average score in mathematics is higher than the average scores in subjects from the same natural science block, namely, in physics and chemistry. We believe that this is an indicator that project activities affect the degree of assimilation of training material.

The analysis of the works of students of different courses and different specialties allowed us to draw the following conclusions:

- In the first semester, most students chose educational projects. The survey of students showed that the applied projects were chosen by those students who graduated from a college or technical school, that is, they already had a professional education. In each of the semesters, all types of projects must be present to choose.
- The interest in project activities among students is very high, most students are ready to continue project activities in further training
- The students noted that the conceptual mathematical apparatus was better assimilated during the implementation of the project.
- Project activity increases the horizons of students and allows us to see interdisciplinary connections.
- Working on the project in a team and sharing responsibility for the result the overall presentation of the results allowed the less prepared students to improve in the knowledge.
- Project activity is more effective only if the student corporations closely with the teacher.

3 Conclusion

Project activity as one of the types of educational activity has shown its viability. There are both positive and negative aspects of using the project method in the educational process [15, 16]. Students are very interested in this type of activity. Students who are engaged in project activities in the semester have a higher level of knowledge in the branches of mathematics studied in this semester than students who are not engaged in project activities. However, in order for the project activity to be more effective, it is invincible to meet the following conditions:

- Close cooperation of the teacher with the student during the project implementation, which entails a large time cost for the teacher;
- Continuous application of the project activity at each stage of training, that is, in each semester;
- It is better to start project activities with the implementation of educational projects, and then move on to the implementation of applied ones;
- Development of interdisciplinary ties from the first day of students ' studies at the university.

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