PROJECT TRAINING IN THE IMPLEMENTATION OF PRACTICE-ORIENTED DISCIPLINES

Pavel Grishmanovskiy, Olga Grishmanovskaya, Andrei Zapevalov

Surgut State University, Russia

ABSTRACT

In accordance with the provisions of the CDIO standards, project-based learning (PBL) allows students to adapt to subsequent professional activities quickly. It is revealed that in the conventional implementation of academic disciplines, not enough attention is paid to project activities. The use of active teaching methods and the acquisition of professional knowledge and skills in the process of project activities can improve the effectiveness of teaching disciplines. An example of the transformation of a single academic discipline using project-based learning, including a system for evaluating students' achievements, is given. Testing of this solution has shown positive effects, such as increasing students' motivation to study, increasing the level of mastering the discipline's material, and increasing the level of students' readiness for project activities. It is noted that a large role in the positive effects obtained is played by the educational achievements evaluation system that is clear to the student. The success achieved allows you to apply the experience gained to other disciplines of the curriculum.

KEYWORDS

Project Activity, Project-Based Learning (PBL), Efficiency, Standards 1, 5, 7, 8, 11

INTRODUCTION

The international initiative for engineering education CDIO offers a number of principles for building effective educational programs, which is why it is widely used in many countries. Many Russian universities have implemented CDIO standards in their educational programs and continue to develop them (Chuchalin, A., Tayurskaya, M., & Malmqvist, J., 2015). Surgut State University joined the CDIO initiative in June 2017 at the 13th International Conference at the University of Calgary with three Bachelor's programs. Two of those education programs are "Control on technical systems" (CTS) and "Software engineering" (SE). At the initial stage, estimates of a number of CDIO standards implementation were quite low, including standards 7, 8, and 11 (Zapevalov, A., Pauk, E., Zapevalova, L., Kuzin, D., & Bezuevskaya, V., 2018).

This is due to the fact that the conventional approach to building an educational program and teaching individual disciplines often does not pay enough attention to project work. Usually, the curriculum contains several separate projects, called course projects, related to certain disciplines in terms of content. This does not provide systematic development of project activity skills. Much more effective is the implementation of project activities within the framework of the implementation of interdisciplinary projects during the entire training period.

However, the current state of the industry and IT requires graduates to be ready for project activities both as part of a team and independently. To do this, it is necessary to develop the student's skills of a project approach to solving professional problems of any scale. This can be both large corporate projects and small production tasks, which are performed in the project format to ensure that the expected result is achieved within the specified time frame.

To do this, it is necessary to transform the teaching process of individual disciplines by implementing the principles of project-based learning when performing current training tasks. Intensive use of project learning is one of the main provisions of the CDIO initiative (Crawley E. F., Malmqvist J., Östlund S., Brodeur D. R., & Edström K., 2014). Surgut State University has introduced an intensive use of project-based learning in educational programs. This article presents the experience of implementing the principles of project training on the example of the transformation of a single discipline.

PROBLEMS OF THE CONVENTIONAL ORGANIZATION OF THE ACADEMIC DISCIPLINE

Conventional teaching includes lectures to familiarize oneself with the material, tests, practical or laboratory work to consolidate the material, and an exam to assess the formation of competencies. The condition for admission to the exam is to perform all control and practical work during the semester before the exam (Figure 1). It is believed that the student will assimilate the knowledge obtained at the lectures, and the implementation of practical tasks will allow one to get the skills to apply this knowledge in professional activities.

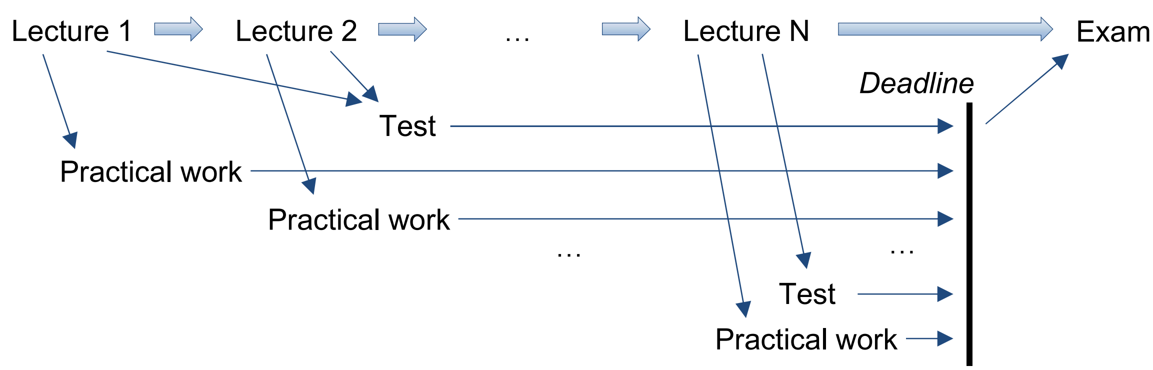

Figure 1. The Traditional Structure of the Discipline

This approach is ineffective for many students. During the semester, the student must complete a certain set of educational tasks, such as tests, practical and laboratory work. The teacher evaluates all tasks and counts them as completed in accordance with certain requirements. Admission to the exam is affected by the fact that the work is completed during the semester prior to the exam. The mark, which is obtained by the student in the exam as a result of the demonstration of knowledge and competencies in the subject area of the discipline, is the final grade for the discipline. Thus, the final grade does not take into account the nature and quality of the student's work during the semester. This leads to a number of negative effects:

- Students often perceive tasks not as an ordered system, but as a simple set of isolated tasks, without a contextual connection between them.
- A number of students have the illusion of having plenty of time. In the absence of sufficient self-organization skills, this leads to the postponement of work to a later date, closer to the end of the semester. At the end of the semester, many do not have enough time to do all the work well.
- The motivation of students is reduced. Many students try to perform only the minimum required amount of work with the minimum required quality in order to get the right to pass the exam in the discipline.
- The exam does not motivate systematic work during the semester, as it is an instant snapshot of knowledge and skills, focused primarily on learning. Memorization prevails over the formation of systemic knowledge, and reproductive activity prevails over practical skills.
- Examination assessment is largely subjective and highly dependent on the psycho-emotional state of the student at the time of the exam.

As a result, students' efforts are distributed unevenly over time and reach their peak at the end of the semester. At the same time, there is a low quality of work, a lack of understanding of the topic being studied, and a desire to provide the result of the work, rather than get it on your own. Students are focused on passing the exam, not on getting practical skills in the subject area. A decrease in students' motivation leads to a decrease in the volume of independent study of the subject, the depth and consistency of its understanding. As a result, the teacher tries to compensate for this by increasing the amount of information transmitted to lectures, which is an inefficient method.

Our experience shows that in each student group, only 2-5 people from 20-25 (8-25%) are able to independently organize their activities in studying the discipline during the semester, systematically and with high quality to complete all academic tasks and demonstrate on the exam Excellent material and practical skills. Up to half of the rest of the students also receive admission to the exam. Often they can answer the exam question well on some topic, but they have difficulty in demonstrating the relationship between the topics of the discipline and in applying knowledge to solve practical problems. Other students do not cope with work on time. They have the opportunity to take the exam later, but, unfortunately, some of them later stop studying due to unsatisfactory results of studying several disciplines.

The structure of the educational program involves the phased formation of learning outcomes that are necessary for the development of subsequent disciplines. The lack of timely planned results of mastering any discipline increases the risk of unsuccessful mastering of subsequent disciplines. If the discipline is the base for a module or a cycle of subsequent disciplines, this negative effect can be disastrous for all further training.

The described situation was observed when students mastered the discipline "Programming and the basics of algorithmization." This discipline is taught in the 1st year for two semesters. It is devoted to the formation of analysis and algorithmization skills, learning the C programming language, and its application to solve problems. This discipline is one of the fundamental for students of "Control on technical systems" and "Software engineering" education programs. The results of its mastering are necessary for the study of many of the following disciplines that are directly related to future professional activities.

PROJECT-BASED TRANSFORMATION OF DISCIPLINE

Positive changes can be achieved by changing the approach to the format of the discipline organization and using the principles of training based on project activities within the discipline. Project-based learning provides students with the foundation for a systematic approach to learning and future professional activities (Rebrin O, Sholina I., & Berestova S., 2014, Nguyen-Xuan, H., & Sato, K., 2018). On the one hand, involvement in project activities is an effective way to motivate students to study the subject area, which is confirmed by real experience (Siong, G., & Thow, V. S., 2017, Pereira de Carvalho, C., 2016). On the other hand, the subject area under study can be used as a material for developing project skills. This will allow us to focus on the study of key points and unify approaches to solving practical problems. A specific action template or "operational template" is generated.

Similar to the iterative development process, when studying a discipline, the necessary competencies can be formed in the course of practical activity in the form of small increments with an assessment of each increment.

In accordance with this, the discipline "Programming and the basics of algorithmization" was reengineered. Lectures were saved, and blended learning was used. The changed structure of the discipline is a set of topics. After studying the material of each topic, a test, an exercise, and laboratory work (task) follow. Thus, the study of each topic is a single iteration of the training cycle – the increment, as shown in Figure 2.

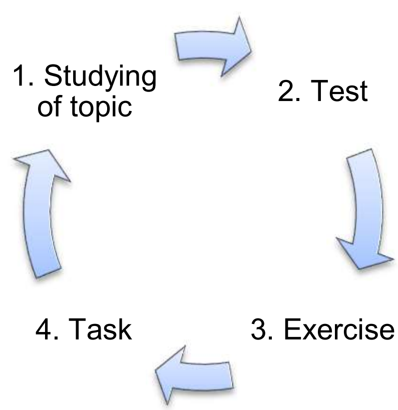

Figure 2. Cycle of Studying One Topic of the Discipline

Blended learning is implemented using the LMS Moodle, which is used at Surgut State University. This system also allows you to set the order of topics, implement the unified structure of the increment, and set the sequence of tasks within it.

When studying a topic, the teacher's lectures are supplemented by the student's independent work with electronic materials on the subject and other sources of information on the topic. Lectures and tests are of a reproductive nature and are aimed at learning, repeating, and assimilating basic knowledge.

The exercises are performed on each topic and are mainly reproductive in nature, without requiring significant knowledge in any subject area and performing search and research work. Each practical task is performed in accordance with an individual option and under controlled conditions – during a classroom session in a computer class within the provided time. The complexity of all variants of the task is approximately the same, but a mandatory requirement is to perform the task independently. At the same time, students have full access to both e-course resources and any information resources in the University's local network and the Internet, except for social networks and cloud storage. The result must meet two conditions: the program must work and match the task. If it fails, the next attempt is provided, usually in the next lesson.

The task has a productive or creative character, requires not only knowledge of the programming language constructs, but also the ability to design the program code, use the means of the programming language to solve subject problems, and perform search and research works. The problem is solved by the student both during classes and independently.

The exercise and task differ in volume and complexity, but both require a project approach based on the product lifecycle. Thus, any task involves the following phases:
- analysis and formalization of the problem – corresponds to the Conceive stage;
- getting the design solution and its justification – corresponds to the Design stage;
- implementation of the solution in the form of program code – corresponds to the implementation stage;
- assessment of the adequacy of the solution and its presentation – corresponds to the Operate stage.

Thus, the activity carried out within the exercise is a short-term project (ST-project), and the task is a medium-term project (MT-project).

When performing ST-project as a simple, practical exercise, this procedure does not require much effort from the student but is a guarantee of success. Working on the MT-project, as a solution to a more complex task includes the preparation of a technical report that describes the results of each stage. This side of the project activity is associated with the formation of documentation and presentation skills. The teacher evaluates each stage of development, which allows timely and purposeful adjustment of the process of forming both project and subject competencies.

Thus, all practical activities during each semester of discipline development are a series of ST-project and MT-project lasting from tens of minutes to several weeks. Projects that do not require much time making it possible to quickly get a result, see errors and weaknesses of work. Multiple repetitions of this process with successive complexity of tasks give an understanding of the advantages of the project approach.

Students easily perceive the project approach, master the process of distributing tasks by stages of the project. Thus, an operational template for project activities is developed and fixed. In the future, they transfer this template from small tasks to more complex ones.

In addition, in the second semester, the process of studying the discipline "Programming and the basics of algorithmization" is supported by the implementation of the course project. In the course of its implementation, a software product must be created to solve a given range of tasks in a particular subject area. From the point of view of training, the purpose of the course project is a comprehensive application of programming tools and techniques, demonstration of the project approach application to solving problems in the professional field. This type of activity within the discipline is a long-term project (LT-project). Thus, the overall structure of the discipline is presented in Figure 3.

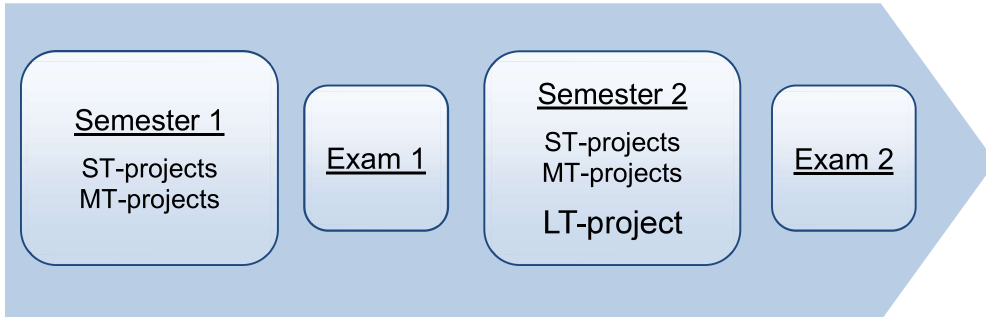

Figure 3. General Structure of the Discipline

As a result, the discipline implements three types of multi-scale projects that have a number of common conceptual parameters, such as the target, conditions, deadlines, and so on. The values of these parameters for different types of projects are shown in Table 1.

Table 1. Properties of Training Projects

Properties	Project types		
	Short-Term Project (Exercise)	**Medium-Term Project** (Task)	**Long-Term Project** (Course Project)
Target	Program	Program	Application
Requirements	Training (specific to the topic)	Functional (specific to the topic)	Functional and non-functional
Conditions	Means of the current and previous topics, classwork only	Means of the current and previous topics	Programming language and OS
Time limit	20-60 minutes	2-4 weeks	1 semester
Outcomes	Source code	Source code, technical report, brief speech	Source code, executable, design and user documentation, product presentation

Time parameters (terms and duration of projects) depend on the volume and complexity of the topic being studied, and the complexity of practical tasks. Each topic is based on the previous ones and includes a number of items, such as the syntax and semantics of the studied language constructions, peculiarities of their use, relationship to other topics, the relevant standard library functions, etc. Figure 4 shows the short names of the topics and shows the time distribution of their respective projects, as well as the place of LT-project in the overall structure of the discipline.

ACHIEVEMENT ASSESSMENT SYSTEM AND STUDENT MOTIVATION

The transformation of the structural organization of the discipline naturally leads to a change in the principles of assessing the quality of its development. The main idea, which shows the importance of a systematic, timely, and thorough performance of all training tasks, is that the final assessment of the discipline includes both the assessment received on the exam and the assessment of the work during the semester. This motivates the student to complete all training tasks on time and with the best results.

Assessment of the student's work during the semester in the final grade is 70%. Of these, 40 points are for performing laboratory work (MT-projects), 20 points are for performing exercises (ST-projects), tests and working with information sources, and 10 points are for attending classes. The last part encourages direct communication with the teacher and the timely completion of training tasks.

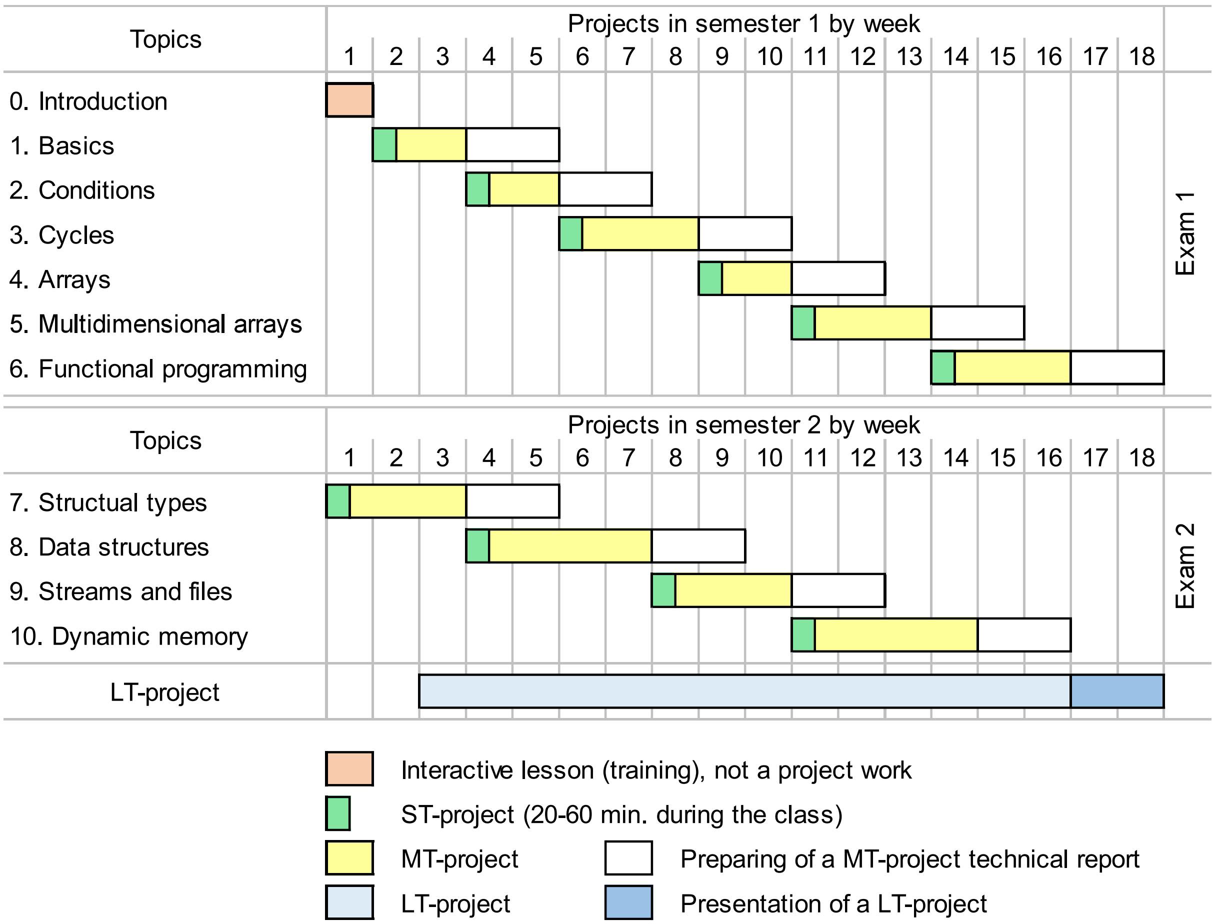

Figure 4. Detailed Structure of the Discipline

The remaining 30% of points a student can get on the exam, including 20 points for solving exam problems and 10 points based on the results of a conversation on the content of the discipline.

As a result, a student can get up to 70 points out of 100 for practical work, which is evaluated not only by its results in overall but also by the results of each stage of each project. This emphasizes the importance of applying practical skills of the project approach to solving professional problems and is a strong incentive for students. An additional incentive is bonus points that a student can get for excellent results, solving problems of increased complexity and more.

CONCLUSIONS

This paper presents the practical results of implementing project-based learning to improve the effectiveness of students studying the discipline "Programming and the basics of algorithmization," which has a practical orientation. The study material of the course is the basis for the mastering of the project approach, with the student personally performs every stage of the project and acts in each role.

The presented transformation of the discipline showed high efficiency both in terms of objective indicators and in the opinion of the students themselves. Having clear goals, evaluation criteria, sequence, and deadlines for completing tasks allows you to achieve the best results when using project-based learning. The number of students who completed all the tasks in time and passed the exam in the discipline "Programming and the basics of algorithmization" in 2016 was 17.5%. Since the start of the transformation, as the proposed approach has improved, this indicator had increased to 53.3% in 2019. Many students perceive the study of the discipline as a game or competition with well-known rules, which makes the learning process dynamic, arouses the interest of students, and contributes to the development of competencies. According to a student survey, 68.2% expect the same approach when studying other applied disciplines. The survey was conducted in 2019 among students who began to study the discipline "Object-oriented programming" after completing the discipline "Programming and the basics of algorithmization."

The positive experience gained in implementing the discipline "Programming and the basics of algorithmization" allows us to expand the application of this approach. The transformation of the next discipline, "Object-oriented programming" is planned. Further, the experience will be extended to a number of other practice-oriented disciplines.

REFERENCES

Chuchalin, A., Tayurskaya, M., & Malmqvist, J. (2015). Development of CDIO Academy in Russia. Proceedings of the 11th International CDIO Conference, Chengdu University of Information Technology, Chengdu, Sichuan, P.R. China, June 8-11, 2015.

Crawley E. F., Malmqvist J., Östlund S., Brodeur D. R., & Edström K. (2014). *Rethinking Engineering Education: The CDIO Approach* (2nd ed.) New York: Springer.

Nguyen-Xuan, H., & Sato, K., (2018). The educational influences of project design education on students` learning abilities (The first report). Proceedings of the 14th International CDIO Conference (pp. 272-283), Kanazawa, Japan: Kanazawa Institute of Technology, June 28 – July 2, 2018

Pereira de Carvalho, C. (2016). Project based learning: an approach to one robotic cell design. Proceedings of the 12th International CDIO Conference (pp. 346-355), Turku University of Applied Sciences, Turku, Finland, June 12-16, 2016

Rebrin O, Sholina I., & Berestova S. Interdisciplinary Project for Bachelor Engineering Program // Proceedings of the 10th International CDIO Conference, Universitat Politécnica de Catalunya, Barcelona, Spain, 2014.

Siong, G., & Thow, V. S. (2017). The effect of using "leaning-by-doing "approach on students` motivation in learning digital electronics. Proceedings of the 13th International CDIO Conference (pp. 194-203), University of Calgary, Calgary, Canada, June 18 – 22, 2017

Zapevalov, A., Pauk, E., Zapevalova, L., Kuzin, D., & Bezuevskaya, V. (2018). The initial experience of educational programs' modernization within the CDIO concept in surgut state university. Proceedings of the 14th International CDIO Conference, Kanazawa Institute of Technology, Kanazawa, Japan, June 28 – July 2, 2018. Available online: http://www.cdio.org/files/document/file/75_Final_PDF.pdf

BIOGRAPHICAL INFORMATION

Pavel Grishmanovskiy, Ph. D. in Computer Science, Associate Professor of Automation and Computer Systems Department. His current research focuses on software engineering, the application of open data in education, information representation, and processing with ontology-based intelligent information systems.

Olga Grishmanovskaya, Postgraduate, Lecturer of Automation and Computer Systems Department. His current research focuses on software engineering, massive open online courses, and the application of open data in education.

Andrei Zapevalov, Ph.D., is Associate Professor and Head of Automation and Computer Systems Department, Surgut State University. Mr. Zapevalov collaborates with Russian higher education institutions on the issues of development of engineering education and project-based learning. He is responsible for the development and implementation of educational programs in accordance with the worldwide CDIO Initiative. Currently, his research is focusing on robotics and curriculum development.

Corresponding author

Ph. D. Andrei V. Zapevalov
Surgut State University
1 Lenin Avenue
Surgut, Tjumen obl., Russia 628412
Phone:+7-922-790-1050
zapev@mail.ru