

Experience in the use of modern educational technologies in teaching professional disciplines of training direction “Civil Engineering”

Svetlana Maksimova^{1,*}, *Zoya Kutrunova*¹, *Lev Maksimov*¹ and *Andrey Voronov*¹

¹Industrial University of Tyumen, Volodarskogo str., 38, 62500 Tyumen, Russia

Abstract. The article considers the applying of CDIO approach elements in Industrial University of Tyumen to bachelor students of “Urban Civil Engineering and Municipal Facilities” and “Water Supply and Sewage” departments, direction “Civil Engineering”. The authors analyzed in detail the methods of lessons conducting by CDIO Standards “Integrated Curriculum”, “Integrated Learning Experiences” and “Active Learning”. Business game scenario “The operating company chooses a company - producer booster pumps” is given in the article. During the game, students had the opportunity to test their professional skills in the real-based simulated situation. Roles of the game participants are described in detail. The methodology for the classes to implement the interdisciplinary project “Design of the sewer system of urban area” is explained in detail. Initial data for the interdisciplinary project were drawn from the teachers’ own practical experience.

1 Introduction

The modern system of education in Russia is in the stage of comprehensive modernization. Updating of basic education programs is need to improve the quality of higher education in Russia[1]. The development of engineering education is nowadays-top priority. Graduates of engineering education programs must to knowhow to use their knowledge and experience for future professional self-development [2].The engineer must be able to plan and design the technical objects, processes and systems, to manage the process of their creation and operation [3]. Students should memorize facts, definitions and principles, as well as learn how to use the gained knowledge to solve specific practical problems. Graduates should be able to choose an effective methodology of design, to evaluate the results of their calculations. They should learn how to work as a team [4,5,6]. Teamwork helps students to improve management skills and to become able to imagine the strategic development of an organization or a department in which they work [7,8]. The graduate should be able to solve multidisciplinary tasks [9,10].

*Corresponding author: msv020761@yandex.ru

Formation of graduates' competencies is the topical task of the modern training of students in universities. The concept CDIO (Conceive, Design, Implement, Operate) is a systematic and comprehensive approach to the design, implementation and evaluation of the quality of modern programs of basic engineering education. Currently, this international initiative was implemented by more than one hundred universities all over the world. The declared aim of the CDIO approach is: university's graduate in engineering should be able to come up with a new product or a new technical idea, to carry out all design works and put them into real business [11,12,13].

The necessary engineering knowledge and skills should be formed at students during the whole period of study at the university. In future, the graduate should be able to master new competencies. Ability to develop new competencies helps to find a job [14,15]. Formation of the personal orientation and readiness for professional work at the future engineers should be conducted in conditions of innovative educational activities [16].

Currently passive transmission of information from teacher to student is an inefficient way of training. Application of game educational technology in the teaching of professional disciplines contributes to acquire the necessary professional and universal competencies by students. Using the results of the implementation of the educational project "CDIO Initiative" allows each graduate to apply their theoretical knowledge base for solution of professional engineering tasks [17].

The standard of the approach CDIO "Active Learning" proposes to create a situation for the students on practical class, so they could try themselves in roles modeling engineering activities [11].

Elements of CDIO Approach can be implemented in business games and related interdisciplinary projects. When developing business games teachers should be approached carefully to their content and scenario [18].

Related interdisciplinary projects put students in a broad and active design environment where they learn to use engineering knowledge, and exercise their communication, project management, leadership and other skills [19].

2 Professional competences formatting of the "Civil Engineering" students

2.1 Identification of problems in teaching students of training profile "Urban Civil Engineering and Municipal Facilities"

Industrial University of Tyumen is not an official participant in the implementation of CDIO approach in Russia.

The first graduation of bachelors of educational profile "Urban Civil Engineering and Municipal Facilities" was held in 2015 by main authors of the article. State Examinations Commission has analyzed the results of the protection of final qualifying works of specialists and bachelors on the profile "Urban Civil Engineering and Municipal Facilities".

The Commission noted that with equal amount of training hours and the number of subjects in the curriculum, the bachelor students have less professional competences. Members of the commission concluded that the "presence in the profession" is important for the formation of the graduate. Training direction of "Building design and urban planning" of the Industrial University of Tyumen recommended to the lecturers, participating in the realization of the basic educational program, use a real project tasks and active learning methods. It is necessary to carry out interaction of professional education with the professional community [20].

2.2 Business games application experience to educational process

Imitation of real activity is the main task of training in the form of a business game. Business game should be conducted, where students have learned the basic theoretical course material. Preparation for the lesson in the form of a business game begins with informing students about the form of the training, its subject and the purposes. Then the teacher divides the training group into subgroups. Students determine the leaders and assign roles on their own. Then subgroups' leaders determine range of issues, found the most important from them for discussion. For the success of the games the teacher should prepare an audience, means for displaying the information, management tools, computer equipment.

During the game, students learn to collect and analyze information that is necessary for decision-making. They should evaluate the accuracy and amount of collected information, the efficiency of received decision. At the same time students form the communication skills. Business game takes place during one practice lesson. Students prepare for the game on their own.

In preparation for the game the teacher should describe the situation, determine the sequence of the stages of the game, distribute the steps in time, establish a procedure for interaction between participants, prepare regulatory and reference data. The teacher should plan for the participants in the game uniform and continuous workload. During the game, it is necessary to avoid situations that lead to loss of time on waiting for the decisions and work results. In addition, the teacher should develop a system of encouraging and evaluation of students' activities. The teacher should assess each student individually. Head should sum up the game necessarily. Each participant of the game should be able to express their opinion. Discussion of results better for spending by the conference.

Let us examine an example of a business game, implemented with the second year students of the direction "Civil Engineering", training profile "Urban Civil Engineering and Municipal Facilities". Theme of the game is "The operating company chooses a company - producer booster pumps". The objectives of the business game: check in practice the assimilation of theoretical material on themes "Booster installation of internal water supply" and "Water supply pumping stations"; development of students' skills in searching, gathering, processing and analysis of the technical, economic and other information; forming students' communicative competence.

The following the actual situation was presented to the students. The group residential buildings were put into operation. It was found that on the upper floors of buildings is not enough water pressure. It requires change booster pumps in the reconstruction of the water supply system of group of residential houses. Course of the game was planned by the general procedure of business games.

In advance, students chose their roles: employees of the company, operating residential buildings (chief engineer, engineer of production and technical department, head of economic department, lot master), representatives of different manufacturers of pumping equipment (pumping plant "Valet", Kataysky pumping plant, HMS Livgidromash, German concern WILO, Danish company GRUNDFOS), demanding apartment owners of residential buildings.

According to the script game action takes place in the office premises of the operating company. The object of imitation is a meeting of the tender committee for the selection of the supplier of the pump equipment. The students playing the role of representatives of the operating company sit at the table of the presidium. Representatives of the companies - pumping equipment manufacturers and tenants of houses occupy seats in the hall. The student playing the role of chief engineer begins meeting. He holds a meeting according to Housing Code and the laws that guide the moment real control of the company. Chief engineer tells the date, time and purpose of the meeting, represents participants -

representatives of factories for the production of pumping equipment. He declares the necessary technical characteristics of pumps: pump capacity, pump head and installation location.

Then, a toss for the representatives of the firms held to determine the order of their presentations. Students playing the roles of the representatives of the firms speak with previously prepared presentations. In the presentation the following information must be submitted: foundation date of the company, company's place in the world ranking of pumping equipment manufacturers, location of services, technical characteristics and advantages of company equipment, proper conditions for its operation. All the players have to ask questions to representatives of firms.

Part of the graduates of training profile "Urban Civil Engineering and Municipal Facilities" in the future professional activity will work foreman in operating companies that serve dwelling houses. Foreman must be able to correctly assess the technical characteristics and conditions of service.

During the game foreman asked the following questions. What is the service life and the order of service of the stuffing box or cartridge seal of pump? How and on what parameters will the rotating speed of pump with a frequency converter be varied? What is the type of pressure sensor used? Where is the pressure sensor installed?

Other questions troubled the residents of houses. What will the source of funding for reconstruction? For how many will the price of utilities be increased?

Previous head of the economic department has spent a feasibility comparison of variants of pump of various manufacturers. He announced the results of the analysis of different options of the selection of equipment at the meeting.

Students playing the role of owners of apartments on 1-2 floors of buildings refused to pay for reconstruction. The reason for the refusal is that they did not have disruptions in the water supply when the old equipment worked. Legally correct engineer explained the rights and responsibilities of owners of premises in apartment buildings. Engineering networks and equipment are the common property for residents. All residents must receive services in their entirety.

At the game's end the chief engineer of the operating company reported about the final decision of the commission. He reports about the type and manufacturer of the pump installation, which will be bought for a group of houses.

During the game the teacher takes a position of cooperation, helps self-realization of students, promotes the development of self-government. In the end the teacher and students sum up the game and appreciate the work of each student.

Duration of work of the teacher in the preparation and organization of the business game was 14 hours. Students received common input data, such as consumption in water supply system, the value of the guaranteed and required head, the cost of electricity. During the preparatory period the teacher consults for workgroups. The names of the companies manufacturing pump equipment was said to students who represent plants. And also the task was given to choose on the initial data: the single pumps, pumping stations with a constant rotation frequency, pump units with a frequency converter. Students must submit the merits of the proposed equipment, find out about shortcomings of similar equipment produced by other manufacturers. Students prepare material in the form of presentations in the program Microsoft Office Power Point.

The teacher wanted to make the game interesting for all participants. By the beginning of the game he produced some provocative situations. In advance the players did not know about these situations. The following are examples of situations. The first, the representative of the manufacturer of pipes made of polymer materials has performed the calculation of required head for pipes from its material, and booster pump was not needed. The second, the representative of the operating company lobbies the interests of one

company which produces the most expensive equipment. Thirdly, the representative of the foreign manufacturer of the equipment has arrived without an interpreter. He talks about the equipment of his company in English.

The results of the game were the following. Students had the opportunity to test their skills in a real situation, to evaluate the correctness of the compiling reports by calculations and the choosing of pump equipment. The players representing operating companies have learned to carry out a comparative analysis of equipment on technical and economic parameters. Previously they have studied documentation on the pump equipment of all companies that participated in the competition. Business game generates a positive attitude towards the profession at students.

2.3 Interdisciplinary project in the training of students of profiles “Urban Civil Engineering and Municipal Facilities” and “Water Supply and Sewerage”

Implementation of CDIO standards in the educational process of the university contributes to the development of professional competencies in students, to the formation at the future engineers the skills of oral and written communication. Student’ motivation increases with project-organized training. Students learn to plan, to design, to produce and to apply their skills in real practice, during work on adjacent disciplinary projects.

Multidisciplinary project was implemented on a practical class in the study subjects “Basics of water supply and sewerage”, “City engineering system”, “Pump and blower stations” with students training profiles “Urban Civil Engineering and Municipal Facilities” and “Water Supply and Sewerage”. An example of the actual practice of teachers attracted as an expert at the state expertise of projects served as a basis for drawing up the task.

In a real situation sewage pumping station was designed during the construction of new buildings in the college food industry, commerce and service. The difficulty of waste water disposal by gravity has been associated with the need to cross street with six-lane traffic by pipe domestic sewage. Construction of a gravity network would require an overlap of traffic on one of the main thoroughfares of the city for a few days. Laying of a gravity network was complicated by the fact that a lot of engineering networks are in the cross section of the street at different depths. Errors in the design, construction and operation of the object, were dismantled in one of the previous lessons.

The task is contiguous project. Design assignment is intended for students enrolled in the direction “Civil Engineering” for different training profiles “Urban Civil Engineering and Municipal Facilities” and “Water Supply and Sewage”. In the design organizations these specialists will carry out different parts of the project.

The purpose of lesson is to teach students of different training profiles to cooperate in fulfillment of the project; create motivation to acquire skills of adjacent training profile.

Students of two groups of profiles preparation of “Urban Civil Engineering and Municipal Facilities” and “Water Supply and Sewage” are on the lesson in classroom. The class is held in the study of educational discipline “Basics of water supply and sewage” and “City engineering system” (for the profile training “Urban Civil Engineering and Municipal Facilities”) and “Pump and blower stations” (for the profile training “Water Supply and Sewage”) in the last third of the semester, when large part of the course has passed.

The teacher divides the students into groups of 5 - 6 people and introduces the task.

Initial data for design include the general plan of the urban area, on which technical college is located (Fig. 1), with applied engineering networks; information about the purpose of the building, the number of users, number of sanitary appliances (Table 1), the depth of soil freezing.

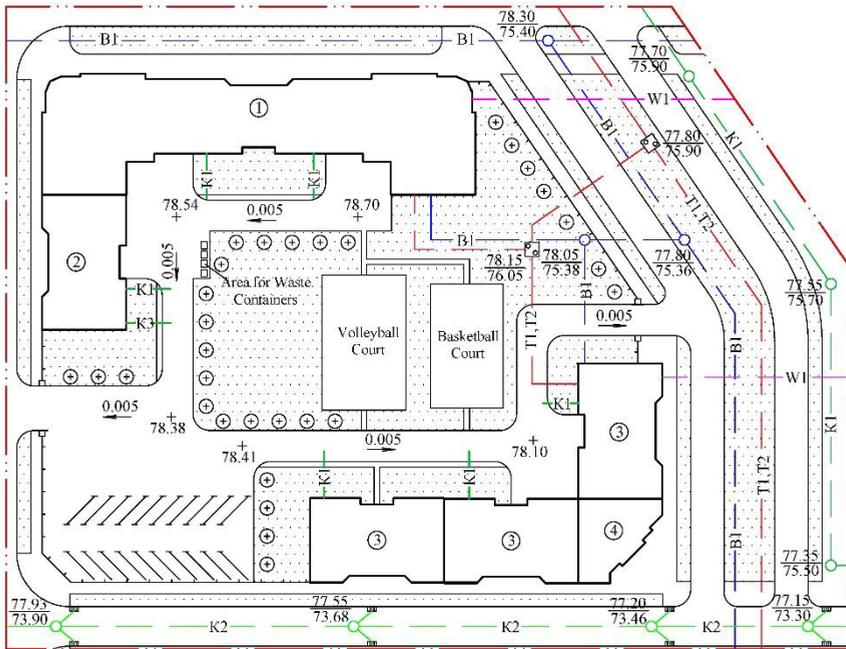


Fig.1 Example of the general plan of the urban area

Table 1. Example of initial data for design

No in the drawing	Name of building	Number of users	Number of sanitary appliances
1	Technical College	560 students и 60 teachers	72
2	Canteen	500 conventional dishes per hour; 1200 conventional dishes per day	50
3	Hostel with shared kitchens and shower rooms on the floors	110 people	55
4	Hostel with shared kitchens and shower rooms on the floors	50 people	25

When the job was creating, it was taken into account that the degree of ownership of competencies among students of different profiles is different (Table 2). At that the degree of ownership on each component of competencies among students of one of the profiles must be at the level of the possession of skills.

Table 2. Degree of ownership of competencies needed for the project

Components of the competences	Training profile “Urban Civil Engineering and Municipal Facilities”	Training profile “Water Supply and Sewage”
Tracing sewage network in dense urban areas	Students have skills	Students have ability
Determination of the estimated water consumption with using the table of summary inflow	Students possess knowledge	Students have skills

Determination of the estimated water consumption according to the method of Building regulations 2.04.01-85 “Domestic water supply and drainage systems in buildings”	Students have skills	Students have ability
Hydraulic calculation of sewage network	Students possess knowledge	Students have skills
Drawing a profile of sewage network according to hydraulic calculation	Students have ability	Students have skills
Design of sewage pump station	Students have ability	Students have skills

As in a real example, the only in this urban area street network of domestic sewage runs along the opposite side of the college wide street with a dividing strip, beneath which engineering networks are laid. Marks of the existing sewer network are selected in such a way that the outlet of sewage by pumping station is the only possible engineering solution.

Lecturer distributes advance students into groups so that in each group a student with leadership qualities is as well as the organization of the project requires the coordination of all team members performing different parts of the draft. In this case competences of standard CDIO Standard 7 — “Integrated Learning Experiences” are realized [11].

Task is intended for execution of the project for four academic hours in view of the protection of project. Members of each project team have to analyze the original data, to determine the point of tapping to the existing sewer network and to trace a designed sewage network considering intersections with the actual engineering networks and distances to the building objects. Given the location of the sewage pumping station, students are required to trace pressure pipeline; to determine the amount of pressure piping, to determine the estimated water consumption and the capacity of pumping station in two ways; to perform hydraulic calculation of sewage network; to build a network profile. After determining the head of sewage pumping station, students must choose pumps; construct the graph of co-operation of the pumps and pipelines; analyze the graph and perform equipment layout and determine the basic dimensions of the pumping station. Graphic part of the completed project must include: consolidated plan of engineering networks territory college; the profile of domestic sewage network; the drawings of the pump station.

For the lesson lecturer should prepare normative and reference literature, pump equipment catalogs. The lesson should be carried out in a specialized large audience with sufficient amount computers.

Lecturer monitors the work of groups in the course of the project. He corrects the work of students, if the decision was made incorrectly. It should be noted that the students find their own original solutions to engineering task, although the location of the sewage pumping station and the tapping point in the existing sewerage network are obvious.

Typical students’ errors are the following: the distances between the projected and existing network engineering services, building objects are not observed; attention is not given to equipment for waste disposal and protection of pumping equipment; pump station is unconnected to the electric networks.

The theoretical material needed to work on the project should be explained beforehand on lectures and practical lessons and secured with independent work. The lecturer can in advance to analyze in detail the task of designing the sewage pumping station with an indication of possible errors and with attraction of an example from the practice with students training profile “Water Supply and Sewage” on the academic discipline “Pump and blower station”. Selection of pump equipment is formed at the skill level at the students of this training profile. Performing the task requires from students of training profile “Water Supply and Sewage” of knowledge and skills acquired during the study of several disciplines, such as “Sewage and wastewater treatment”, “Pump and blower station”.

By the end of the semester the execution of trace of engineering networks was formed on the skill level at the students of training profile “Urban Civil Engineering and Municipal Facilities”. Similar examples were done in practical classes. During the work on course projects, each student performed these actions and coordinated them with the teacher.

Students of different training profiles interact in the course of joint work on the project. Communications and favorable working atmosphere are set. Exchange of knowledge and skills takes place.

Students of training profile “Urban Civil Engineering and Municipal Facilities” should learn to design sewage pumping stations with submersible pumps with the help of students of training profile “Water Supply and Sewage”. These pumping stations are quite common in practice, especially in dense urban.

In their turn, the students of training profile “Water Supply and Sewage” should learn the tracing intradistrict engineering networks that will be require in the future when they will design master plans of treatment plants. With this method students are actively involved in the educational process. They remember more learning material, see the relationship between the previously obtained and new knowledge.

In the merged practical class another one standard CDIO “Integrated Curriculum” is implemented[11].

Experience of working with the staff in the design and installation company shows that graduates having the skills on related training profiles more quickly find work. They are better adapted to the team. Generally, their career advancement is more successful. Our own experience of working in project groups shows that it’s important to understand the actions of engineers who perform other parts of the project. Only in this case, the joint work on the project will be successful. When the engineer having qualification of one of the profiles of the educational training direction becomes the head of the project group, he manages better, because he understands the work of each member of the group.

3 Conclusion

The use of modern active teaching methods such as business games and related interdisciplinary projects is changing the methodology of preparation for classes of students and teachers. These methods develop the professional competence as communication skills and increasing motivation of the future engineers. Application of active methods of acquiring knowledge demands to students’ mental efforts and helps us to reduce passively behaving participants in the educational process.

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