Yu.P. Pokholkov

K.K. Tolkacheva

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CDIO Initiative and Problems of Active Learning Implementation in Engineering Education

National Research Tomsk Polytechnic University
Yu.P. Pokholkov, K.K. Tolkacheva

The article considers recommendations of CDIO Standards on active learning methods and their application to the problems in the system of engineering education. Contradictions between the organization of educational process and conditions for active and effective learning (interactive, practice-oriented, problem-based and project-based learning) are discussed as the main reason of the above stated problems. To overcome the contradictions it is important to make significant changes in the planning and organization of training, as well as in the requirements for qualifications of teachers, that are critical for teachers' ability to use modern methods and techniques to ensure students' involvement in the learning process.

Key words: educational technologies, engagement, learning outcomes, Worldwide CDIO Initiative.

One of the progressive approaches to designing and implementing engineering undergraduate education is an international project that was introduced to the international academic community in 2000 as Worldwide CDIO Initiative. The abbreviation CDIO stands for Conceive – Design – Implement – Operate. CDIO concept is aimed at bridging the gap between theory and practice in engineering education, strengthening the practical values of training using problem and project-based learning.

As a part of the CDIO Initiative 12 standards were adopted, where Standard 8 addresses Active learning methods. Teaching and learning based on active experiential learning methods engage students directly in thinking and problem solving activities within the training process, including process management, ideas analysis and evaluation, experimentation and knowledge discovery.

According to the standards developers, active learning is considered experiential when students take on roles that simulate professional engineering practice, for example, design-implement projects, simulations. The reason highlighting the rationale for setting this standard is given in the thesis that «by engaging students in thinking about concepts, particularly new ideas, and requiring them to make an overt response, students not only learn more, they recognize for themselves what and how they learn. This process helps to increase students' motivation to achieve program learning outcomes and form habits of lifelong learning» [1].

Teaching methods and techniques used in the implementation of educational technology should motivate and encourage students to cognitive activity. The learning process should be organized so that students have the desire to participate more actively in the learning process, to take the initiative, and not just follow the prescribed rules. According to the research study of student involvement there are three types of engagement:

- academic, characterizes students' mental investment, expended effort in the learning process. Criteria for measuring this type of involvement include preparation for classes, homework, participation in classroom discussions, academic achievements;
- social/behavioral, emphasizes students actions and participation in university life outside learning process. Mainly focuses on students' interactions with other students and student communities;
- emotional, encompasses students' feelings of connection to their university, general attitude of students to the university level of support students perceive from members of the university community and their place in this community [2, 3].

Talking about engagement, we cannot ignore the role of faculty, that is expected to use active teaching methods aimed at developing the students' interest, the need for constant self-improvement, self-education, independent research and discovery of new knowledge needed when searching for solutions to the problem. One of the barriers to the adoption of new approaches and technologies in the training of future specialists is the conservatism of university community, and low motivation of teachers to apply modern interactive teaching methods. In response to this challenge the CDIO Initiative provided Standard 10 – Enhancement of Faculty Teaching Competence. If teachers are expected to implement new methods for active experiential learning and learning outcomes assessment, it is important to provide them opportunities to improve relevant competencies by supporting internal and external qualification development programs, forums to share ideas and best practices [1].

Ideas and principles of the CDIO Initiative, addressing identified problems, can be adapted and implemented in various universities taking into account specifics of the educational programs. Today, 117 universities from around the world, including Russia, have joined the CDIO Initiative. Reforming of the educational process in accordance with the CDIO requirements assists in improving the quality of engineering training, also by ensuring involvement of students in the learning process.

Wider implementation of problem-based learning could be one of the possible changes on the way of improving the educational process. Table 1 shows those features that in our opinion distinguish traditional forms of learning from the problem-based ones.

Guided by the Federal State Educational Standard (FSES) for training future engineers, universities define a set of core competencies (professional and general), that students should acquire upon successful graduation from the educational program in the filed of engineering and technology. However, the definition of a set of core competencies is just one of the steps that has to be fulfilled, but not enough for successful achievement of intended learning outcomes by the students. Providing high quality professional training mainly depends on the choice of educational technologies. Learning outcomes may be different at the same educational program and depend on the chosen educational technology. The learning process should ensure active participation of students that allows developing required professional attributes faster and efficiently. Undoubtedly faculty qualification in engineering and pedagogical fields is the essential element to achieve the objectives of the educational process.

According to the Federal State Educational Standards (FSES) the outcome-based approach requires «...vast implementation of **interactive forms** of training (workshops, discussions, computer simulations, business and role-games, case studies, psychological and other trainings) combined with extracurricular activities with the purpose of **students' professional skills** development. The training process should include meetings with representatives of Russian and foreign companies, state and public organizations, workshops provided by experts and high

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Table 1. Specific characteristics of traditional and problem-based learning

	Traditional training	Problem-based learning
1	A large number of lectures, providing the basic content of the discipline (module)	A small number of lectures, integrating a number of topics related to the problem being solved and place students in the context of the real-world problems
2	Passive learning in large groups (25-30 people)	Active self study and teamwork in small groups (6-8 people)
3	Discipline (module) is divided into separate topics	The content of the discipline (module) integrated in problem-oriented case studies within interdisciplinary context
4	The leading role of the teacher, passive knowledge translation	The educational process is aimed at students independent search of information and new knowledge. The teacher acts as a mentor, consultant
5	Form of control of learning outcomes achievement: assessment of knowledge on the subject at the end of training	Degree of graduates' competencies development evaluated within the learning process. Integrated assessment

qualified specialists» [4]. In fact, practice-oriented, problem-based and project based learning are based on interactive forms of training.

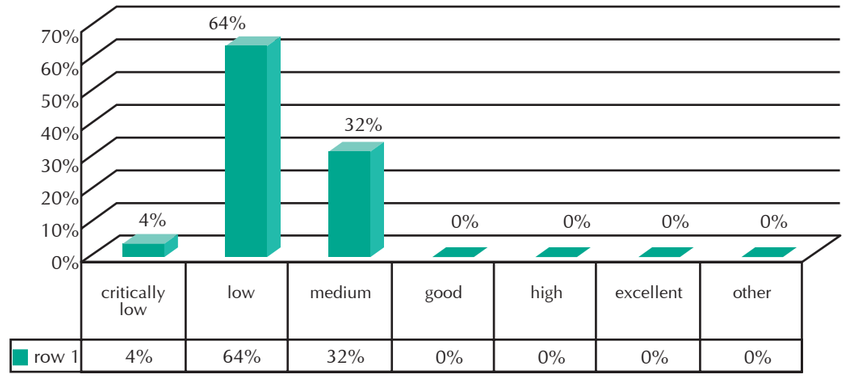
Despite the fact that FSES requires at least 20% of interactive learning in bachelor degree programs and at least 40% in master degree programs, the actual level of interactive practice-oriented teaching methods implementation in Russian universities remains dramatically low (based on the results of study conducted by the Association foe Engineering Education of Russia) [5].

The real implementation of interactive training often faces difficulties and contradicts the system of educational process planning that remains committed to the traditional teaching methods and forms of educational activities.

Experience of Russian universities shows that educational technologies required to ensure the achievement of intended learning outcomes are addressed only at the final stage of educational program designing, after the curriculum structure and academic hours for each discipline are defined. This indicates a sequence of actions confirming the priority of curricula for specific disciplines over teaching methods in educational programs implementation. It also leads to domination of knowledge-based approach over the activity approach in future engineers competence development.

Unfortunately, popular in technical universities traditional approach focused on lesson training system, does not allow achieving expected learning outcomes. Students just require ability to listen and write down instead of active independent work. The most common forms of educational activity are lectures and workshops that do not provide one of the main conditions of motivation for learning – engagement of each student in the learning process. The need for improving changes becomes obvious, primarily aimed at the selection of adequate educational technologies and teaching methods, enhancing their

Fig. 1. Expert evaluation of practice-oriented learning methods implementation in Russian HEI



effectiveness for the development of creative thinking, through transition from teaching to learning, from passive to active methods, from the reproductive activity of students to independent and creative activities [6].

High level of students' motivation and engagement in the educational process, of course, depends on the faculty competence in the field of interactive teaching methods, their ability to organize the learning process, using such techniques as brainstorming, expert seminars, trainings, case study, etc.

Professional qualification of university teachers is also determined by the frequency and duration of their internship at real engineering companies. This also assists in getting more contacts with industry representatives, who later could be invited as experts to give master classes for students on challenging engineering problems of today. A significant role can play business contracts for conducting research permitting to involve students in solving real industrial problems.

Committed to training competitive specialists, leaders and developers of educational programs should pay particular attention to the content and forms of organization of educational activities. The learning process should have such characteristics as outcome based approach, interdisciplinary content, modular and student-oriented structure with possibility to follow individual curricula. The above stated elements should be given sufficient attention at the stage of educational program development.

The implemented educational technologies and methods should contribute to achievement of intended learning outcomes, providing interactive learning, engagement and independence of students, flexibility to the challenges of the external environment, transforming students from passive listeners into active participants in the educational process.

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Activity of The Engineering Teachers Association to Implement CDIO Concepts

South Ural State University (National Research University)
Yu.V. Podpovetnaya

The article examines a new approach to higher engineering education based on the introduction of the CDIO concept. The possibilities to implement the world CDIO initiative standards which enable university faculty to design educational process in the modern way so that students' motivation to learn is constantly outlined. The experience of the Ural Engineering Teachers Association in implementing CDIO concepts to improve educational process is presented.

Keywords: engineering education, CDIO concept, project activity, association of teachers.

Today, Russia has made fast progress in developing international relations, strengthening business activity, globalization aspects that become challenging for the system of higher vocational education associated with appropriate changes to be made. In this regard, there are some dramatic changes in engineering education concerning transition to the team project-based learning.

A new approach to higher engineering education is intended to increase practical training, as well as problem and project-based learning. These aspects are presented in the worldwide CDIO initiative aimed at reforming engineering education [6 -9].

The basis of CDIO initiative was conceived at the Massachusetts Institute of Technology (MIT) in the late 1990s. In 2000, MIT in collaboration with three Swedish universities - Chalmers University of Technology, Linkuping University and the Royal Institute of Technology - founded Worldwide CDIO Initiative [7]. Today CDIO Initiative consists of more than 100 universities around the world (30 countries). In Russia, the following universities became CDIO members:

- Moscow Aviation Institute (National Research University);
- Moscow Institute of Physics and Technology;
- Tomsk State University of Control Systems and Radioelectronics;
- National Research Tomsk Polytechnic University;
- Skolkovo Institute for Science and Technology
- Astrakhan State University;
- Siberian Federal University.

In September 2013 pilot implementation of CDIO approach was launched in the Siberian Federal University (SFU). SFU was given the status of CDIO initiative member on 16-17 January 2014 within the Regional CDIO Meeting in Chalmers University of Technology (Sweden).

The framework provides students with an education stressing engineering fundamentals in the context of Conceiving – Designing – Implementing – Operating (CDIO) real-world systems and products in the international market. This international project concentrates efforts to close the gap between theory and practice in engineering education. The new approach enhances hands-on training also by introducing problem and project-based learning [6; 8].

CDIO creates the necessary context for professional education, address program and curriculum philosophy, involves active

Yu.V. Podpovetnaya