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CDIO Standards Implementaion. Tusur University Case Study

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The paper presents the TUSUR University case study in implementing CDIO Standards. The authors describe how TUSUR University manages to apply CDIO principles at different levels, from one discipline to the whole educational program.

Key words: Worldwide CDIO initiative, CDIO standards implementation, project-based learning, curriculum modernization, distance learning technologies.

According to the remark of President Vladimir Putin, that has been made during his speech at the extended session of the State Council on February 08, 2013, "the main problem of today's Russian economy is its uttermost ineffectiveness. Workforce productivity in Russia stays unacceptably low…". In our opinion one of the reasons for such ineffectiveness is an outdated system of future engineers' training. It is natural that with the transition from industrialized national economy to a knowledge economy new economic fields and professions emerge, requiring miscellaneous training of specialists.

Unfortunately, due to a variety of causes many classical universities get involved in the process of adaptation with a stitch in time. Despite the active evolvement of innovative infrastructure and development of new research trends racing to create the most effective educational approaches, it is evident that educational curriculum as well as teaching methods is not undergoing significant alterations. It is common for Russia and many other countries that educational fields created during the industrialization era cannot keep up with the development of corresponding economic fields, therefore dooming its graduates to employment problems [1, pp. 233-240]. How often do Russian graduates hear when first entering the real production: "Forget all that you have learned at the university, we will now teach you how to work the right way"? Education here contradicts with the social and economy context and seeks for reformation: the solution to the problem is the multidisciplinary projects and project-based learning, close cooperation with corresponding industry on early stages of curriculum development, and more flexible approach to modern competence formation.

In context of slow-speed advancement of national economy and with the aim of its stimulation it is necessary to change the attitude for engineers' training. Liberal creative engineering requires specialists who above having fundamental knowledge are able to set and solve problems, see the whole picture and promote development of scientific and technical fields not only nationally, but on an international level as well. Let alone the fact that such education would raise considerably the competitive performance of Russian HEI graduates when applying for a job. To achieve the goal successfully and provide students with opportunity to advance competences from different fields of knowledge a thorough analysis followed by educational programs reformation is needed. It is also necessary to develop their skills of professional self-development and adaptation in the context of globalization.

However it is improper to believe that the problem of "fulsome fundamentality" is solemnly Russian. European and American scientists and employers became aware of this problem back in early 1990s. As an answer to the challenge a concept of practice-oriented learning, the so-called project-based CDIO Initiative, has been developed. Key elements of the CDIO Initiative replicate life cycle of real systems, processes and technologies, that progresses from idea through understanding and development to management and stabilization, allowing young specialists to have a try in different professional roles. Today over a 100 universities all over the world are united by this idea, 6 of these universities are the leading universities of the Russian Federation.

Historically Tomsk State University of Control Systems and Radioelectronics (TUSUR) has always stood out from the majority of Russian universities by virtue of its bold ideas and pioneering spirit; and it has been proved once again when TUSUR joined the CDIO Initiative in 2013. It was a seamless process due to the fact that back in 2006 TUSUR and its organizational staff has already developed and implemented in educational process structure a "Project-based Group Learning" technology that is to a great extent similar to the CDIO principles. Aiming to support this educational technology and other emerging projects and companies in the University, TUSUR has developed an essential innovative infrastructure: development laboratory, common use centers, student business incubator, technological parks, etc.

Becoming an official member of the CDIO Initiative university association has opened new opportunities for the University in terms of sharing best practices of taxonomy and more profound implementation of practice-oriented learning. Today CDIO Standards are implemented in three Bachelor majors of TUSUR's Institute of Innovation: 27.03.05.62 Innovation, 27.03.02.62 Quality Control and 15.03.060.62 Mechatronics and Robotics.

In accordance with the plan of CDIO Standards integration in University's educational curriculum, students of all three majors have a single educational program for the first 3 semesters complying with each major's standard. This standardization has two core advantages. First of all, joined lectures give a room for saving of educational resources – faculty work hours, classrooms, tutorial and maintenance facilities – without jeopardizing the quality of education on the first stage. This provides a stockpile of resources needed for the stage of specialist formation, when project activity will require extra courses and new disciplines creation, leading to a one-to-one training. Secondly, students have an opportunity for extra career guidance. As a common rule enrollees make a choice prematurely, basing their opinion on parents' views and bright advertisement. It may be quite complicated to make a change once students realized they have made a wrong choice. A unified curriculum during the first semesters provides students with an overview of all three majors and allows them to seamlessly choose a different one if needed. This enhances attractiveness of project areas for students and therefore creates a solid base for project-based learning.

According to the curriculum, Bachelors' project-based group learning starts at the fourth semester. In case it is related to the internships and thesis project such learning proceeds until graduation, i.e. slightly over 2 years. During this limited period a set of actions has to be carried out, i.e. set a problem, conduct research and development actions as well as trial experiments, document the results. This implies that students will get into action right away. However students are not ready for the project activity yet [2, pp. 44-46].

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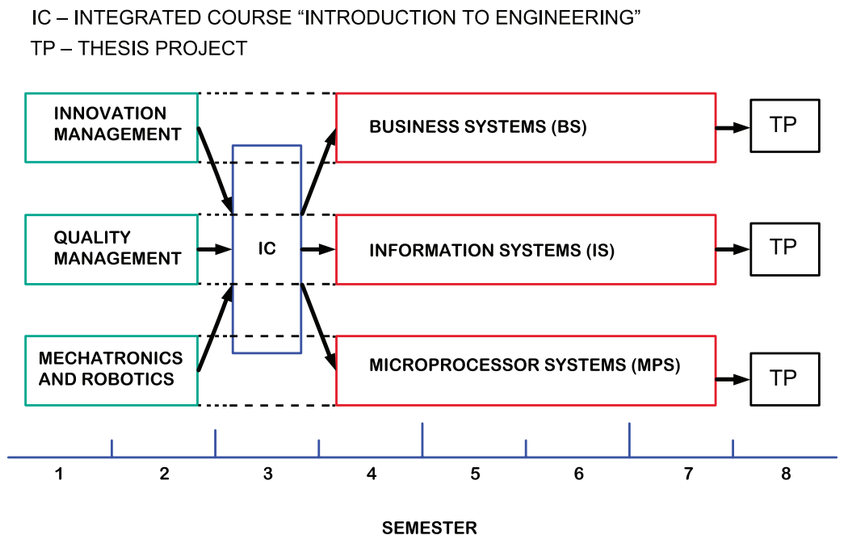
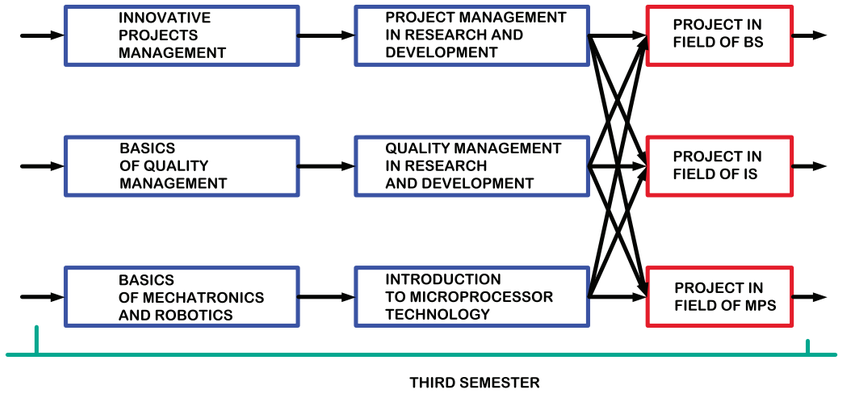
Fig. 1. Integrated Educational Program



Integrated course "Introduction to Engineering" carried out in the third semester is designed to prepare students for the project-based group learning. Background for the course is provided by three courses of the integrated curriculum: "Innovative Projects Management", "Basics of Mechatronics and Robotics" and "Basics of Quality Management". The first two are the courses of federal component for "Innovation" and "Mechatronics and Robotics" programs and therefore are the extension of a first-year course "Introduction to Profession". "Basics of Quality Management" is a part of the University educational programs component and serves for the same purpose for the "Quality Management" program. Implementation of an integrated project for all three courses enables specification (clarification) of the courses' content. Integrated course is built upon a project and comprises first stages of project execution – predesign research, project requirements development, draft evaluation of risks and project costs, and determination of the next stages (semesters) of the project [3, p. 189-194]. Besides, the course ensures a general overview from the position of project management, quality management and microprocessor systems development. In addition University organizes visits to industrial companies in Tomsk and invites practical engineers to give lectures.

Implementation of the Worldwide CDIO Initiative Standards and execution of an own Project-Based Group Learning fully corresponds to the modern trends in international engineering education development, where knowledge paradigm of education is replaced by the active-learning approach, putting TUSUR on one level with world educational leaders, such as Massachusetts University of Technology (USA), Chalmers University of Technology

Fig. 2. Integrated Course "Introduction to Engineering"



(Sweden) and others. However it is essential to keep in mind that world of engineering thinking does not have territorial boundaries, and international aspects of project-oriented learning should not be left out. At the moment a complex challenge is set for universities of the world, which is to train technically competent entrepreneurs, scientists and engineers, who focus their activities on global development and understand interdisciplinary and cross-cultural connections, as well as know at least one foreign language. TUSUR's answer to this challenge is presented in the Net Project-based Learning Concept. The aim of the project is to stimulate development of international creative teams within a framework of specific projects. The project implies existence of four key components:

- increase of practice study hours within specific projects;
- constantly enriching data base and methods of self-education;
- close ties between university and industry;
- development of a project within an international team.

TUSUR has already been conducting such projects for several years. A successful example of the Net Project-based Learning Concept realization is a joint educational course «Global Software Engineering» organized together with Ritsumeikan Asia Pacific University (APU) and dedicated to software development. In 2012 the project leader, developer and main lector, Professor Victor Kryissanov from Ritsumeikan University invited his colleagues from TUSUR to participate in the project with the aim to broaden course's content and make it more practice-oriented.

Aiming to carry out this educational project teams of Russian and Japanese students are formed each fall semester. Moderators define project theme for current semester collaboratively. The theme is given in a generalized manner, normally only the basic technologies are discussed, for example "neural interface" or "humanoid robot". Specific content of the projects will be formed by student teams during educational process.

Major part of the course consists of online courses on both distributed software

development and specific technologies proposed for the semester. Lectures on technologies are led by guest specialists. Thus in fall semester of 2012-2013 lectures on social networking analyses were delivered by professor Uwe Serdьlt from University of Zurich, in fall semester of 2013-2014 professor Tomasz Rutkowski from University of Tsukuba gave a speech on neural interfaces and Eugene Shandarov from TUSUR discussed NAO humanoid robot. However the core elements of the course are not the lectures, but rather collaborative student work on projects. Project execution is provided by two virtual teams; each of them consists of equal number of students from Kyoto and Tomsk. These teams have to accomplish the following tasks on a competitive basis:

- Prepare CVs for each participant.
- Outline roles in the team (programmer, designer, team leader, presenter, etc.)
- Choose subgroup leaders (Japan, Russia) for effective cooperation.
- Select communication channels (as a rule, the main communication channel is e-mail, however it could be Skype for collaborative software and hardware trials).
- Specify project's theme based on the proposed wider themes.
- Prepare project's presentation for midpoint project defense.
- Ensure collaborative project execution (software code writing, hardware preparation, detailing of each module's specifications, etc.)
- Conduct collaborative trial experiments.
- Prepare and make presentation and demonstration for project defense.

Thus attendees of the Global Software Engineering educational course not only get theoretically acquainted with distributed software development methodology, but conduct projects using this method by themselves. Owing to the roles outline within teams each student has an opportunity to actively and efficiently participate in the project. It is also essential that communication within teams as well as the education process is conducted in English language, which is a foreign language for both Russian and Japanese students. Real practical results that have to be shown at the final presentation of the project serve as an extra incentive for a more thorough work within the project.

During the 2013-2014 semester two projects on NAO humanoid robot management through neural interface have been conducted. One was designed for development of an application that provides aid for kids with "attention deficit disorder", the other one was aimed at development of robots' remote control system. One of the projects' unique features was that all work concerning neural interface has been done in Kyoto and the one with NAO robot has been conducted in Tomsk. All the trial experiments and developments presentations have been made via free access Internet channels in real-time mode. Projects results have been presented in three conference reports and one thesis paper.

Opportunity for participation in international projects is a strong motivation that leads students to their knowledge enhancement and, besides teamwork skills, provides students with such an important quality as a habit of self-education. It is insufficient to simply download information from the Internet and listen to a course of video lectures from a distinguished professor. It is necessary to have the ability to see aspects of practical knowledge implementation and understand which of the variety of courses will be useful within a specific project.

Owing to the existing educational system and educational methods of the TUSUR Distance-learning Institute students are able to obtain access to the University educational resources not depending on their location. This allows students to constantly improve their professional skills and broaden their professional horizons. Thus Net Project-based Learning leads to student's transformation from a listener to a man of action. Educational process is retargeted, emphasis are shifted from theory to practice. And most significantly the process of knowledge and skill assumption is deliberate and directly related to execution of real-life tasks [4, pp. 19-23].

Summarizing all of the above we can conclude that an intensive and effective modernization of educational curriculum in accordance with the Worldwide CDIO Initiative Standards takes place in TUSUR. The success of this experience is mainly based on historical prerequisites and both moral and infrastructural readiness to accept the changes: longstanding experience of Project-based Group Learning, distance learning technologies, equipped laboratories, innovative infrastructure, including student business incubator and center for engineering creativity. All of these ensures a more balanced pass to a new evolution level of University's educational practice and raises chances for TUSUR graduates' employment. Young engineers trained within this ideology will not be a burden for the enterprises during the adaptation period, but will rather be able to introduce a new vision and take part in optimization and modernization of the production process.

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