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Implementing CDIO as a Tool for NArFU Programs

Northern (Arctic) Federal University named after M.V. Lomonosov (NArFU)
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This article describes the enhancement of upgraded engineering education programs based on international CDIO standards within the framework of Northern (Arctic) Federal University n.a. M. Lomonosov.

Key words: engineering education, CDIO Initiative, module-integrated curriculum.

In the last few decades the priority of RF socio-economic development has been constantly considered with reference to the exploration and development of the Arctic region itself. In view of the fact of the growing geopolitical and economic significance of the Arctic and its vast resources, the big challenge in engineering education redirects the thrust of engineering programs towards the personnel training and re-training to work in arctic conditions and solve the problems listed in "Development Strategy in RF Arctic Region and National Security Protection, through to 2020"[1]. The major tasks stated in this document involve the following: effective chrome, manganese, tin, aluminum silicate, uranium, titanium and zinc mining within the Arctic Ocean islands, Kola Peninsula, Polar Urals mountain massif; development of Timan Pechora petroleum province and hydrocarbon reservoirs in the continental shelf of Barents, Pechora and Kara Seas and Yamal and Gydan peninsulas; as well as the development of marine service complex, including marine geological exploration, application of fibre-optic and communication satellite systems and their monitoring and hydrometerological and ecological safety and security services; Arctic transportation infrastructure development, facilitating the Northern Sea Route as an integrated national transport route throughout the RF; improvement of Arctic ports and establishment of modern port-production complexes in the RF Arctic Region and other zones [1].

Under these circumstances the mission of the Northern (Arctic) Federal University n.a. M. Lomonosov (further NArFU) involves the training of highly-qualified personnel for the exploration and development of Russian European North and Arctic, which, in its turn, defines engineering education as the priority orientation included in its education policy.

Since 2012 NArFU has been implementing the project "Engineering Education" focused on university-wide education process improvement in different engineering majors via enhancement of international CDIO standards, which would shape the relevant engineering competencies in priority areas of the North Arctic Region, as well as perspectives of its development in view of the existing possibilities and regional demands.

To implement this project a charter was formulated which embraced the goals and tasks, domain and feasibility study, assumed results, risks and, finally, the project phases. According to the adopted charter there are three phases in the project implementation of improving the training system of engineering personnel: preparatory phase (September 2012 – August 2013), project phase (September 2013 – August 2014) and pilot phase (September 2014 – June 2018).

Preparatory phase included the following: analysis of international CDIO Initiative materials [2; 3]; benchmarking of Bachelor curriculum in priority majors for further technological development of economics in North Arctic Region; benchmarking of convergent education in domestic and foreign universities; audit of engineering education programs in NArFU; and questionnaire survey in engineering training for stakeholders.

According to the final analysis of above-mentioned facts, it is obvious that there is no systematic interaction between the employers and the training program majors as an employer is involved only in the education process itself, i.e. in the initial phase of the program implementation, while further interaction in the project and assessment phases is rather insignificant. Other evident factors are that many instructors have no internal motivation to change not only the teaching content but also its technologies, and most instructors lack those necessary competencies in modern engineering didatics, in particular, project management. Consequently, even well-developed, sought-after education programs are of underdemand for employers.

Survey for employers conducted by the Department of Education Evaluation Monitoring (NArFU) showed that the relevant global trends are influencing NW Russian employers' demands and requirements to engineer-graduates. In employers' view the engineer-graduate cultural competencies (so-called "soft skills"), including system thinking, management, project, team-work, negotiation, leadership skills, as well as responsibility are rather insufficient. However, 89% of employer-respondents consider that the above-mentioned competencies are very important in job placement and in further professional activities.

Many employers indicate that universities should enhance training in the domain of professional occupation rights, as well as early introduction not only into the professional engineering domain, but also into production and technology spheres, especially, before planned internship. They also highlighted such important factors as updated teaching content and technology in terms of existing global trends.

Based on obtained and analyzed preparatory phase results the following issues were adopted: incorporating the device of regulatory, organizational, procedural and informative-consulting support for education-business partnership at the university level and implementing T&E activities (i.e. professional development) in engineering didactics for the university academic staff.

To implement the project the following pilot curricula were defined within the framework of five NArFU institutes:

- 23.03.03 Operation and Maintenance (O&M) of Transport-production Machines and Systems (Bachelor degree in Engineering), major – "Service of Transport and Production Machines and Timber Complex Facilities";
- 15.03.02 Technological Machines and Equipment (academic qualifications), major – "Engineering of Technological Machines and Equipment"
- 18.03.01 Chemical Technology (Bachelor degree in Engineering);
- 09.03.01 Computer and Information Sciences (Bachelor degree in Engineering), major – "CAD System" and "Integrated Automatic Systems";
- 09.03.02 Computer and Information Sciences (Bachelor degree in Engineering), major – "Design and Maintaining IT Systems";
- 08.03.01 Building and Construction, (Bachelor degree in Engineering), major – "Highways".

Project phase included the shaping of instructor CDIO competencies (Standard 9 – international CDIO Initiative). Within the NArFU institutes team groups were organized. The responsible executives of these groups were certified against the

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"CDIO Initiative in Engineering Education" within the framework of the co-project "CDIO Academy: 21st Century Engineering Education" between SKOLKOVO Institute of Science and Technology and National Research Tomsk Polytechnic University.

The first session of the CDIO Academy was in January, 2014 in Chalmers University of Technology (Guteberg, Sweden), where the CDIO Initiative participants discussed the leading practical applications of CDIO concepts and standards in different Russian and foreign universities. The second session was in Tomsk Polytechnic University (Tomsk) in March, 2014, while the final session including the project review of the participants, was conducted in May, 2014, in SKOLKOVO Institute of Science and Technology (Moscow).

Project members became familiar with the training experience of engineering personnel (Bachelor engineering modules) in the Ural Federal University, as well as participated in relevant workshops, organized in Immanuel Kant Baltic Federal University (Kaliningrad).

Besides, the above-mentioned sessions in CDIO Academy, information dissemination and shaping CDIO competencies of University instructors were conducted through training workshops in pilot NArFU institutes.

Shaped competencies addressed the possible go-ahead decision of this phase- designing education programs in accordance with CDIO standards. Project members in co-operation with employers and under the supervision of the NArFU Academic Development Department, conducted re-engineering of the pilot education program. As a result, module-integrated curricula were designed (Fig. 1), in terms of the pilot education programs (Standard 3 – international CDIO Initiative).

These curricula included such a discipline as "Introduction to Engineering" (Standard 4 – international CDIO Initiative: Intro to Engineering), which, in its turn, embraced the fundamentals for accepted engineering practice in product, process and system development and shaping basic personal and interpersonal skills [3].

Based on the analysis of cultural and engineering competencies stated in the Federal Education Standards, as well as the employer-respondent questionnaire results, the modules of basic humanities, mathematic and natural sciences were defined.

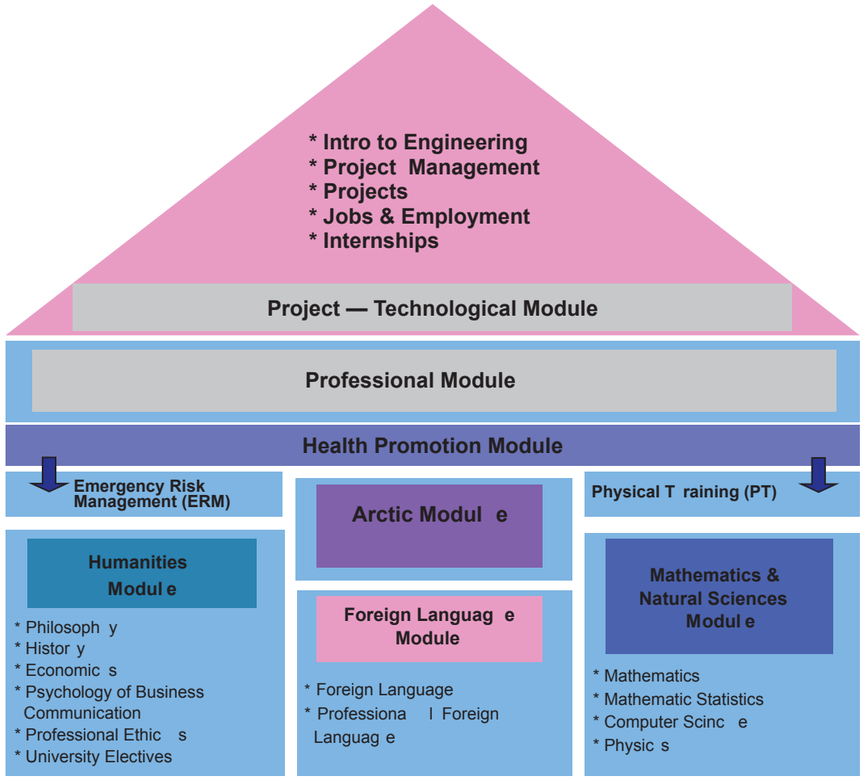
The humanities module included such disciplines as "Professional Ethics" and "Psychology of Business Communication" as tool subjects in developing integrated cultural competencies for further curriculum module studies (Standard 7 – international CDIO Initiative: integrated learning) [3].

To develop project-innovation competencies, the Project-Technological module was designed including "Intro to Engineering", "Project Management", execution of three projects within the framework of different 1-3 course year disciplines, as well as an engineering project as a part of the graduation paper (Standard 5 – international CDIO Initiative: implementation of project-innovation activities) [3].

In respect to the University mission the "Arctic" module was integrated into the curriculum, the content of which was determined by the domain specification and types of professional (engineering) activities of this or that education program. This module task was to identify the current issues in developing the RF Arctic Region and those professional (engineering) activities which are specific under the existing Arctic conditions. This module embraced the possibility of solving current problems and tasks defined by both the University and regional administration.

The pilot phase was launched in September, 2014. This phase included not only the implementation and problem-solving of the teaching process organization itself, but also the further advanced training of the academic staff, the interaction mechanism of stakeholders within the framework of the education program

Fig. 1. Model of module-integrated curriculum



via organization management of basic education departments, customization of education quality monitoring techniques to evaluate the education process and the results of curriculum implementation in compliance to CDIO standards (Standard 11 – international CDIO Initiative: learning evaluation), policy performance of preparing team-groups for project management (Standard 6- international CDIO Initiative: collaborative workplace for professional (engineering) activities and developing professional system management for graduates [3].

At present this phase is still in progress. Concepts, stated in international CDIO Initiative are being visualized in the developing curricula. It is obvious that the effective evaluation of the upgraded engineering education system could be conducted through longitudinal monitoring. However, during this phase, the project members have developed a solid understanding in the following: significance of systematic and continuous enhancement of the curricula, commitment in updating the module content, acquisition and implementation of favorable technologies, and demand in a constant interaction with stakeholders.

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Коллективная проектная деятельность в системе «студент – кафедра – ИП» как средство формирования профессиональной компетентности

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Рассматривается участие студентов в хозяйственно-договорной проектной деятельности инженерной кафедры с позиции соответствия Идеологии CDIO. Проводится анализ степени участия студентов в этапах планирования, проектирования, производства и применения. Выявляются возможные направления развития хозяйственно-договорной деятельности в рамках модели CDIO.

Ключевые слова: проектно-ориентированное обучение, хозяйственно-договорная деятельность, проектная деятельность, модель CDIO.
Key words: Project-Based Learning, business activities, project activities, CDIO model.

Высокий уровень распространения инициативы CDIO в современном образовательном сообществе и успешный опыт применения стандартов CDIO лучшими техническими университетами мира позволяют с уверенностью говорить о том, что образовательная модель Conceive – Design – Implement – Operate («Планировать – Проектировать – Производить – Применять» или «Задумай – Проектируй – Реализуй – Управляй») представляет собой одну из наиболее эффективных, если не эталонную модель организации образовательной деятельности, нацеленной на подготовку компетентных специалистов. Ведущие технические университеты России солидарны с мировым сообществом и рассматривают внедрение принципов CDIO как высокий потенциал развития. В настоящее время к инициативе CDIO присоединились 12 российских университетов, первым из которых стал Национальный исследовательский Томский политехнический университет [1].

Неотъемлемым фактором внедрения CDIO на базе вуза является содействие руководства университета в вопросах модернизации учебных планов, обучении преподавателей современным педагогическим методикам, популяризации принципов CDIO, формировании инфраструктуры, позволяющей организовать проектную деятельность на всех ее этапах, и др. С момента присоединения к Инициативе в ТПУ реализован ряд мероприятий, обеспечивающих полное или частичное соответствие образовательной деятельности инженерных направлений таким Стандартам CDIO, как стандарты 2 (Результаты обучения), 3 (Интегрированный учебный план), 4 (Введение в инженерную деятельность), 6 (Рабочее пространство для инженерной деятельности) [2, 3].

Однако даже при наличии в вузе стратегической цели по адаптации принципов CDIO, процесс внедрения концепции внутри университета происходит по-разному, иногда несистемно. Зачастую университет определяет одно или несколько (как, например, в ТПУ) образовательных направлений/специальностей, подготовка по которым модернизируется в соответствии со всеми стандартами и планируемыми результатами

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