UDC 378.141.4, 378.14.015.62

Experience and Further Reflections on Practice-Based Learning Development at Omsk State Technical University

Omsk State Technical University
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The article discusses experience and prospects of practice-based learning development at Omsk State Technical University (OmSTU) through the establishment of resource centers and basic academic departments in corresponding enterprises, as well as implementation of CDIO standards.

Key words: practice-based learning, resource center, base chair, CDIO, educational program.

Major Soviet Russia enterprises of many industries such as aerospace and aircraft engineering, transport machine building, precision tool engineering were accumulated in Omsk. Their high level of technological intensity is guaranteed by high-quality engineering staff, predominantly from Omsk Polytechnic University.

Fundamental knowledge gained in 5 years at the university was thereafter reinforced with practical skills which graduates "young specialists" obtained over first 3 years of working experience in a definite enterprise. It was this period when new employees gained practical skills, or as they say now "competences", under supervision and control of experienced workplace supervisors. That was the way for a "real" engineer to grow.

During 1994-2008, many industries of manufacturing sector, which were located in Omsk, faced serious stagnation. There was lack of cooperation between higher professional institutions and manufacturing enterprises. As a rule, such cooperation implies internships and involvement of specialists in student progress assessment. Having graduated from universities, majority of young engineers chose a different career path. Therefore, they have lost their theoretical knowledge and have not gained any practical skills. It means that they will never become "engineers".

Now comes a new period, when it is obvious that economy of the country should be based on manufacturing sector. Enterprises gradually started to recover and increase their potential within contemporary framework. Engineers having sufficient knowledge in new equipment and machinery are in high demand. However, due to new economic conditions, not all enterprises can employ graduates and patiently wait when she or he becomes a "real" engineer. The other challenge is that duration of higher professional education has been changed from 5 years (in fact, 8 years) to 4 years.

A serious problem has arisen – how to enhance the quality of engineering education under new conditions, i.e. to expand student practical training in limited duration.

At the first stage, Omsk State Technical University (OmSTU) focused on the establishment of resource (innovative) centers. A new quality level of educational process was provided by spending money on purchasing the most up-to-date equipment required to deliver training within definite education programmes. Such resource (innovative) centers facilitate student learning by engaging them into real

production process and research. Besides, these centers offer various advance programs and refresh courses for the employees of manufacturing enterprises. A total of 12 resource (innovative) centers have been established at OmSTU (Table 1).

The most successful and effective resource centers are those which have already repaid the expenditures:

- Modern Techniques in Mechanical Engineering.
- Research Institute of Radio Electronics and Instrument Engineering.

100% of the graduates in the programmes supported by these centers are annually employed.

Table1. Resource (Innovative) Centers and OmSTU Basic Academic Departments in Enterprises

Resource center (name; profile/ specialization code*)	Basic academic departments (name, location, profile/specialization code*)
1. Modern techniques in mechanical engineering 15.03.05	1. Department "Aircraft Engineering" in Production enterprise "Polyot" – branch of Khrunichev State Research and Production Space Center, 15.03.05; 24.03.01; 24.04.01; 24.05.01
	2. Department "Gas-Turbine Engine Manufacture" in OJSC "Omsk Engine Design Bureau" 15.03.05; 24.03.01; 24.04.01; 24.05.02
	3. Department "Production Facilities Operation" in OJSC "Vysokie tekhnologii" 15.03.05
2. Pressure metal treatment and foundry technologies 15.03.01	4. FSUE "P.I. Baranov OMO" branch of FSUE "MMPP "Salut" 15.03.01; 22.03.01; 22.04.01
3. Welding in civil engineering 15.03.01	
4. Research Academic Resource Center of Nanotechnologies 22.03.01; 22.04.01; 28.04.02	
5. Auto transport service 23.03.03; 23.05.02	5. Department "Hydromechanics and auto vehicles" in OJSC "Transport Machine Construction Plant" (OJSC "Machine-Building Design Bureau") 13.03.03; 23.05.02

** Profile/specialization codes are given in accordance with the order № 1061of the Ministry of Education and Science of the Russian Federation dated September 12, 2013 № 1061*

6. Power supply	6. Omsk branch of Quartz Group, Inc 13.03.01; 13.03.02
7. Energy efficiency 13.03.01; 13.03.02; 13.05.01	
8. Research Institute for Radio Electronics and Instrument Engineering 11.03.01; 11.03.02; 11.03.03; 11.04.03; 11.04.04; 11.04.01; 11.04.04; 11.05.02; 12.03.01; 12.04.01	7. Department "Construction and Radio Electronic Equipment Technologies" in: PJSC «Omskiy Nauchno Issledovatelskiy Institut Priborostroeniya» (basic education programmes); Production Association «Irtysh» (advance programmes); Scientific Research Institute NII Neptun (advance programmes); JSC "Saturn" (advance programmes) 11.03.03; 11.04.03; 11.03.01; 11.04.01; 11.03.02
	8. JSC "Tsentral'noe konstruktorskoe byuro avtomatiki" 11.03.03; 11.04.03; 11.03.01; 11.04.01; 11.03.02
9. Information technologies 02.03.03; 09.03.01; 09.03.02; 09.03.03; 09.03.04; 10.03.01	9. "Satori-Partner", ltd. 09.03.03
	10. ISS "Art"
	11. limited company "Tele2-Omsk" 27.03.03
10. Hydrocarbon Pipeline and Tank Design 18.03.01; 21.03.01	12. "Gazpromneft-ONPZ" 15.03.02; 15.04.02;18.03.01; 18.04.01
	13. ONHP "Oil and Gas Engineering" 15.03.04; 18.03.01; 21.03.01; 27.03.04
11. OmSTU-FESTO 15.03.04; 27.03.04.	
12. Polytest 15.03.03	
	14. Scientific and technical complex «Cryogenic technique», Ltd. 15.03.02; 15.04.02; 16.03.03; 16.04.03
	15. JSC "Omsk Map Reproduction Plant" 29.03.03; 29.04.03

The next stage was to establish basic academic departments (workspaces) of OmSTU in corresponding enterprises. A total of 15 departments have been founded (Table 1). The idea was to attract industrial facilities and intellectual assets of the enterprises to teaching process during senior years.

It is a fruitful experience for students to become familiarized with the different aspects of real manufacturing, to do research on the specific topic assigned by enterprise's specialists, which in its turn significantly contributes to facilitating practical competence of OmSTU graduates and assists them in adapting to their new professional roles.

We also seek other ways and means.

Having analyzed the educational experience of leading Russian engineering universities [1, 2] and European Engineering Schools [3, 4], the decision to train specialists through practice-oriented learning technologies on the basis of CDIO standards (Conceive, Design, Implement, Operate) has been made.

One of the main reasons for choosing this particular approach to modernize engineering education is that CDIO standards can be easily adapted to the education programmes offered by OmSTU, which have been developed in accordance with the Federal State Educational Standards (FSES) of the Higher Professional Education. Besides, the experience that has been already gained could assist in implementing the above-mentioned standards.

The needs analysis of the military-and-industrial complex enterprises located in Omsk region, as well as examination of university facilities and analysis of university faculty have revealed that it is more effective to implement CDIO standards into master's degree programmes. It is this degree or level of education when it is possible to focus on developing practical skills relevant to inventive work, conceptual design and design-implement experience, which are the appropriate context for engineering education.

Since 2014-2015 academic year, several master's degree programmes offered by OmSTU have been delivered so that they could meet all of the CDIO standards, i.e. international educational project (Table 2).

These master's degree programmes have been developed by request of military-and-industrial complex enterprises located in Omsk.

Table 2. Master's degree programmes delivered in accordance with CDIO standards

№	Master's degree programme	Programme outline
1	Mechanics of small unmanned aircraft vehicles (15.04.03)	The programme is intended to train specialists and experts who will be capable of designing and operating small unmanned aircraft vehicles.
2	Design of machinery production fixtures and tools (15.04.05)	The programme is intended to train specialists and experts who will be capable of designing nonstandard fixtures and tools for modern machinery production.
3	Aircraft design (24.04.01)	The programme is intended to train specialists and experts who will be capable of developing, manufacturing, operating and modernizing rockets and rocket-space complexes with due regard to environmental safety.
4	Design and optimization of power-supply systems (13.04.02)	The programme is intended to train specialists and experts who will be capable of designing power-supply systems of different complexity, solving the problems related to power-supply system modernization and optimization.

The main focus of student training in the mentioned programmes lies within the profound theoretical knowledge and practice, in-depth study of profession-related courses which are aimed at design engineering and scientific experiment in accordance with enterprises' requirements within the framework of federal national project implementation. These federal national projects are among the ways to boost Omsk region development.

As OmSTU has no right to apply its own educational standards in teaching process, the master's programmes in question have been developed on the basis of FSES of the Higher Professional Education and international CDIO engineering education principles. There is no contradiction between the Federal State Educational Standards and CDIO principles.

Programme educational objectives and learning outcomes have been reviewed and validated by key stakeholders including university faculty, students, alumni and representatives of industrial enterprises for relevance to engineering practice (Standard 2).

Mutually supporting disciplinary courses are the basis of the master's programme curricula (Standard 3).

Alongside profession-related courses, the curricula of these master's programmes also include general courses which are delivered in all master's programmes: "Introduction to Engineering", "Economic Feasibility of Design Solution", "Mathematical Modelling and Information Technologies in Design". These courses are intended to develop personal and interpersonal skills knowledge, skills, and attitudes. The course "Introduction to Engineering" is compulsory in all master's programmes and provides a framework for engineering experience acquisition and essential personal and interpersonal skills development. The main focus is on the role and responsibilities of an engineer, oral and written communication, as well as design-implement experience (Standard 4).

The course "Economic Feasibility of Design Solution" is intended to provide understanding of the issues related to the principles of engineering systems economics and feasibility studies.

Active experiential learning methods are widely applied at OmSTU. The regulation 75.03-2012 "On application of active and interactive teaching and learning methods in education process" has been approved and put into execution (Standard 8).

Since 2013 the application of active and interactive teaching and learning methods are specified in course curricula. To reveal whether students are satisfied with learning outcomes, as well as introduction of active teaching and learning methods, OmSTU conducts student survey on a scheduled basis.

The learning process is supported by relevant resource centers and the potential of the basic academic departments (workspaces) established in the corresponding enterprises, which allows students to be engaged in practical work, collaborative discussion of the problems to be solved (Standard 6).

Master's students from the programmes in question build teams made up of about 3-5 people. These teams are supervised by scientific advisors who are leading scientists and researchers having their own scientific schools and associations in the corresponding sphere. Students who enroll in the master's programmes are expected to do at least two research projects aimed at acquiring experience in design-implement activity, with the level of complexity being increased. The second project is planned to be carried out as a part of research-and-development activity and on the basis of industrial enterprises (standard 5).

Funding of much of the work done mainly comes from the Program of OmSTU strategic development and extrabudgetary resources. Further funding is planned to be directed at purchasing required equipment, developing teaching materials, providing professional training of university faculty, etc.

The work that has been done at OmSTU is just the beginning. In future, it is planned to revise and modernize all master's, bachelor's and specilist's degree programmes offered at OmSTU.

OmSTU, being a member of university-enterprise consortium, won a competition of European Union's programme for enhancing quality in higher education TEMPUS. The project title is "New model of the third cycle in engineering education due to Bologna Process in BY, RU, UA" (NETCENG)".

The project is aimed at developing a pilot model of the third cycle in engineering education (post-graduate programmes) in accordance with the regulations and up-to-date recommendations of Bologna Process.

The project objectives are:

1. to develop, implement and accredit basic and additional ECTS engineering education programmes including new principles of post-graduate programmes;
2. to develop innovative teaching methods and educational setting for prost-graduate programmes;
3. to bring universities of partner countries and labor market closer.

The duration of the project is 36 months.

Within the project, OmSTU is in charge of developing the course in design of robotic onboard systems of automatic maneuverable space vehicles in order to address the challenges in non-cooperative rendezvous in space, i.e. large-sized space rubbish, interorbital towing, space vehicle refueling, replacement of onboard equipment, disorbit, etc.

Conclusion:

Implementing practice-based learning at OmSTU on the ground of resource (innovative) centers, basic academic departments established in corresponding enterprises and CDIO standards will contribute to enhancing the quality of engineering training within bachelor's, master's and specialist's degree programmes and assist in resolving the issue of human resources in military-and-industrial complex enterprises. The proposed model of engineering education allows university to train such a specialist who does not need to be retrained after graduation in order to be fully engaged into professional activity.

REFERENCES

1. Chuchalin A.I. Academic Programme Objectives and Learning Outcomes // Vysshee Obrazovanie v Rossii. – 2014. – № 2.– P. 5-15.
2. Dmitriev S.M. Interaction Between a Technical University and the Departments under Enterprises / S.M. Dmitriev, T.I. Ermakova, E.G. Ivashkin // Vysshee Obrazovanie v Rossii. – 2014. – № 2.– P. 73-80.
3. Remaud B. European perspectives on the competences of engineering graduates // Engineering Education. – 2013. – № 12. – P. 12-21.
4. Guidance on Design Master's Programmes in Accordance with European Standards EQF and EUR-ACE / O.V. Boev, A.A. Kriushova, E.S. Kulyukina [et al.]. – Version 2.0. – Tomsk, 2013. – 94 p.
5. Standards and Guidelines for quality assurance of Bachelor', Master', and Specialist' programs within priority areas of National Research Tomsk Polytechnic University (TPU Academic Standard) / edited by A. Chuchalin. – 4th edition. – Tomsk, 2012. – 204 p.