

PROJECT MANAGEMENT TECHNOLOGIES AS A TOOL FOR TRAINING A NEW GENERATION OF ENGINEERS

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Abstract

The increasing pace of technological progress on the way to the fourth industrial revolution is already started in the global industry requires a new quality of staffing. It actualizes the search for effective mechanisms and technologies for sustainable reproduction of a new generation of engineering cadres. The problem is particularly acute for the industrial regions of the country. The Ural Federal University has become a base for the formation of a new generation of engineers in the Ural region. In order to create a regional system of continuous training for technical specialists, the university has developed a portfolio of projects for the system of training for elite highly qualified staff.

The article investigates the practice of project management technologies in the educational environment of the Ural Federal University.

The main objective of the authors is to study the specificity of application of project management technologies for engineering education.

Research analysis is performed with the use of the methods of document analysis, data integration, benchmarking, constructive correspondence and case methods. The findings of researchers are also based on the evidence of the expert survey conducted among the engineers of major industrial enterprises of the Ural region.

Key words: project management technologies, engineering education

JEL Code: I21, I23, H43.

Introduction

Over the past ten years processes and technologies of project management are successfully implemented in the practice of engineering education. Analysis of Russian and foreign literature shows that objects of design in educational practice have heterogeneous nature and distinguished by subject areas and levels. The objects of designing are the content of education and means of educational process (de los Rios-Carmenado and others, 2015; Gilsenan and others, 2013; Wei and others, 2010) pedagogical technologies (Chuchalin and others, 2011; Huang and others, 2015; Kulgina 2013; Misfeldt and others, 2015; Zwikael and

others, 2015), as well as the educational system of the institution as a whole and the management processes it (Brienikova and others, 2010; Liu and others 2011; Wang and others, 2013). Educational projects of different directions as usual combined in a program / portfolio of educational projects, it allows using project methodology and projecting funds as mechanism for more efficient management. How it goes in leading university of Ural Region – in Ural Federal University?

1 Background

Results of researchers that held in 2013 and 2015 were supposition to explore practice of integration of project technologies in university. For study problems and perspectives of regional engineering education in 2013 was held an inquiry of engineers of big industrial enterprises of the region by applying a questionnaire survey (N=240).

Tab. 1: The significance and the level of development of core competencies of the modern engineer in estimates of practicing engineers (in points)

Criteria	Assessment of competences		Gap „Δ Importance – Presence”
	Importance	Presence	
Ability to work independently (selection of research problems, methods, educational path)	4,5	3,1	1,5
Interaction experience with real sector of the economy	4,3	2,8	1,5
Communication skills (ability to perform your work, discuss your ideas)	4,3	3,3	1,3
Presence of complex understanding about your field, understanding of economic contests of its functioning	4,2	3	1,4
Participation in international and research projects	4,1	2,8	1,5
Experience of participation in group projects	3,9	2,8	1,4
Ability for multicultural communication	3,5	2,8	1,3
Average assessment	3,9	2,9	1,3

Source: own description based on (Bannikova and others, 2013).

Results of questionnaire survey show that there is significant spread between desired competences on the enterprise and present ones of graduates of technical specialities. The most serious gaps are in competences such as «Interaction experience with real sector of the economy» (spread in 1,5 times), «Presence of complex understanding about your field, understanding of economic contests of its functioning» (spread in ¼ times), «Participation in international and research projects» (spread in 1,4-1,5 times).

Results of 2013 year were confirmed of exclusive data 2015 year that we got from semi-formal interview with one of the directors of engineering projects of large machine-building

enterprise of the region. Object of the assessment – competences of beginning design engineer, the most needed specialty in the field of machine building, especially in regions. The basis of the interview was CDIO Syllabus map (Chuchalin and others, 2011), is an international reference model of learning outcomes of technical specialists. Required and present competences were evaluated on 5 points scale.

Tab. 2: Assessments of development levels of present and expected competences of beginning engineer in big industrial enterprises (in points)

Criteria	Assessments of competences		Gap „Δ Importance – Presence”
	Importance	Presence	
1. Technical knowledge and thinking			
1.1 Essential and fundamental engineering knowledge	5	3	0,6
1.2 Advanced and fundamental engineering knowledge	4	2	0,5
2. Interpersonal competences: team work and communication			
3.1 Team work	4	2,6	0,7
3.2 Communication	4	2	0,5
3.3 Communication on foreign language	4	1,7	0,4
3. CDIO- Conceiving, Design, Implementation and Operating of systems on enterprises and in society			
4.1 External and social context	5	2,5	0,5
4.2 Entrepreneurship and Business context	5	2,7	0,5
4.3 Conceiving and engineering system	5	1,7	0,3
4.4 Design	5	3	0,6
4.5 Implementation	5	3	0,6
4.6 Operating	5	3	0,6

Source: own description

Comparative analysis of data on scale «importance-presence» shows significant differences in assessments of important competences and its real existence in graduates of technical universities. We can see the biggest differences in competences that are related with project activity: ability to work in team, knowledge of design technology, management and operating in sphere of technical projects.

In general, there is a discrepancy between the quality of project preparation engineering cadres and requirements of modern production and development objectives of economy. There are no effective mechanisms of interaction of industrial companies and academic institutions in the process of training. On the face the contradiction between the need in modernization of the regional economy and deformation of the reproduction process of the engineering cadres.

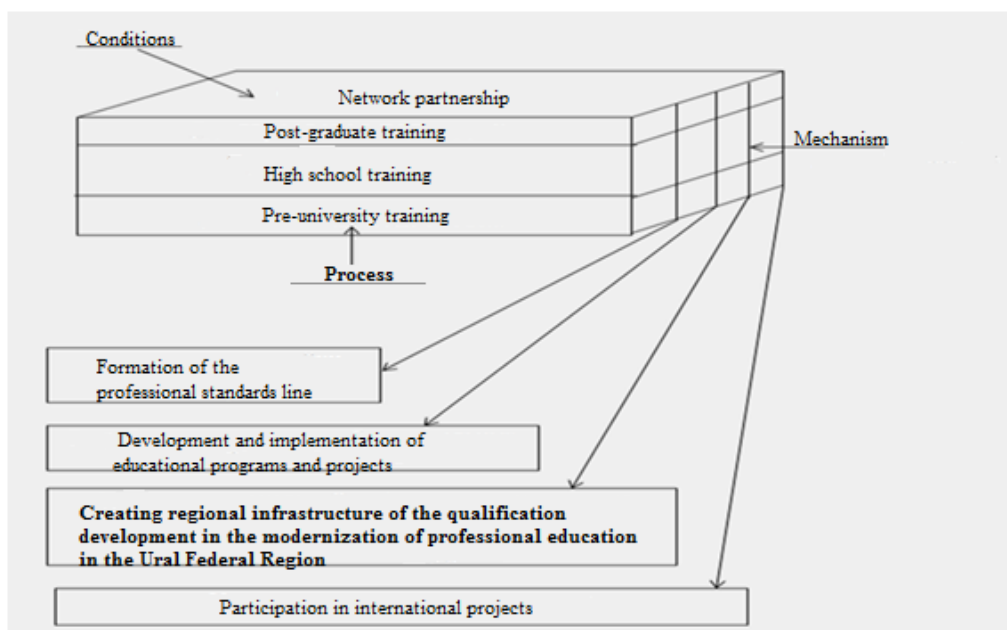
2 Project management as a mechanism for the formation of a continuous system of training a new generation of engineering

In the Ural Federal University (UrFU), High Engineering School (School) is the center responsible for the strategy of preparation of the new generation of engineering cadres, the implementation of new models of engineering education, providing training of world-class experts for the development of priority areas of the regional economy.

School today is a center of methodological design of the new generation educational programs, is a kind of testing ground for new forms of interaction with the business. The strategic aim of the School is to create a system of continuous engineering training.

School has been realizing a sustainable reproduction model of the new generation engineering cadres in the Ural region since 2011 year (Figure 1).

Fig. 1: The model of sustainable reproduction of the engineering cadres of the Ural region



Source: own description based on the (Bannikova & Boronina, 2013).

The model includes three levels: - pre-university, higher and graduate training of technical cadres in the region. Process of sustainable reproduction of the engineering cadres of the Ural region is carried out in several directions: the formation of the professional standards' line; development and implementation of new educational programs and projects in accordance with international standards; establishment of a regional structure of qualifications in the modernization of vocational education; participation in international projects. Mechanism for implementation of the model are the tools of project management on the basis of the network partnership.

By the constructive correspondence method, we evaluated the practice of design at the School, its compliance with international standards of project-management and engineering technology.

Tab. 2: Compliance of the design practice with the international standard of project-management

Advantages	Disadvantages
Conducting pre-design studies which support the relevance of the project and its main directions	Underestimating the use of tools of planning time - Gantt charts and network schedule
Creating the Project Office	Use of mostly quantitative parameters performance evaluation of projects
Development of official documents of the project	Lack of control changes content of projects
Institutional subsystems of the project - time management, team, cost, risk, communications, quality.	Underestimating the methods of optimal design in the development and evaluation of projects
Using the methods of cost control	
Using the local design technology, ensuring the implementation of the principles of comprehensiveness, coherence and complementarity.	Low design culture of teaching staff

Source: own description based on the (Project Management Institute, 2013; Boronina and others, 2015).

In the UrFU, along with the traditional linear-functional structure, implemented project-oriented management model. Project Office is designed to initiate and support the management of educational and infrastructure projects at the university. The main functions of the project office is archiving of projects, their regulatory support, training of the project activity's key actors, projects multimedia support, the formation of the intersectoral cooperation mechanisms between project participants.

Project Management System functions as a combination of the following processes: the study of potential projects; their initiation; project planning and organization of work; formation of the project team and its management; planning and control of time, cost, quality of the project; implementation and monitoring of the project; change management. The main structural positions of each project are reflected in the main project document - the Charter. For example, in the basic school project «Establishment of a system of continuous engineering training UrFU» are listed: the timing of the project, the project cost, project description, justification of the project (identification of problems), goals / indicators of a subroutine which includes the project, the main objectives of the project (structural partition of works), indicators of the project, the project boundary, project risks, minimization of possible project risks, related projects. On the main idea of the project - the creation of a system of ongoing engineering training - work-related projects such as the creation of the program «International bachelor» to prepare schoolchildren, the acquisition and adaptation of

engineering programs modules of leading foreign universities, development of the «double diploma» programs and other practices network interaction. Connected projects that reflect local technology and design mechanism to ensure continuity of the engineering elite formation, that achieve the objectives of the megaproject on creating a system of continuous engineering training in the region.

However, staffing of projects in doubt. By a recognition the developers themselves, one of the significant limitations of design practice is the unwillingness or lack of motivation of the teaching staff be included in these projects. Unlike commercial companies, operational work in the university is almost always a priority than design. This requires finding a balance between the current activities and project work of teachers. Favorable financing of projects, unfortunately, does not involve the allocation of expenditure to encourage faculty members. Finally, a monitoring system of project results is poorly understood. Developed performance criteria for projects primarily are quantitative, do not involve the formation of a system, aimed at feedback. There are no monitoring models, focused on obtaining estimates of key projects' stakeholders- students, parents, teachers, employers.

3 Design of the professional standards and educational programs

The major component of the innovation economy is the formation of a well-functioning labor market. There is a need for the development and implementation of infrastructural projects such as inter-organization aimed at the establishment of national and regional systems of qualifications, professional and educational standards, the creation of new educational programs. In this regard, significantly increases the role of the projects' environment, the need to create the effective management communications systems.

In the process of formation of regional qualifications systems arise new forms of public-private partnerships, federal-regional cooperation, there is a revision of the existing external and internal functional relationships of various agencies and departments, which indicates the reality of network interactions of organizations in achieving significant results for all. Ural Federal University is the methodical center on the development of professional standards, the development of basic and additional educational programs, establishment of an independent assessment system and qualifications certification.

The process of professional standards' developing is more efficient if the work of the project team attended by people that are directly related to the production process (master or worker, foreman, etc.). Appropriate communication structures are necessary and during design of

basic education programs. The logic of design involves the formation of learning outcomes - the program's objectives - the modular structure of the curriculum - content of modules. Developing the program attended by experts- developers of professional standards, representatives of the company, the leading teachers of the departments of the institute. The educational program is created in close cooperation of educational institutions and enterprise-customer and implemented at the sites of the University and enterprises with the involvement to the educational process the leading practitioners.

4 Implementation of the project training technology in the educational process

Formation of engineering elite responsible for the formation and sustainable reproduction of the multidisciplinary project teams, focused on international standards of engineering and have world-class competencies. The need to form an open educational environment correlates with the need for new educational technologies. The basis for the formation of an open learning engineering educational environment engineering served as international project "Initiative CDIO» («create-design-implement-operate»). According to the initiative, design and promotional activity – it is a practical activity in which students design, manufacture (build, create), test and use real objects, processes and systems or their models (Chuchalin and others, 2011).

As shows the best national and international experience, practice-oriented, project-based learning on a regular student performance on technical projects of increasing complexity is a successful direction of students' training who are able to think independently, to generate constructive ideas, make decisions and seek their execution of technicians. While studying at this ideology, students gain the necessary experience in the production of teamwork, and the practice of submitting and protecting their own ideas, responsibility for decisions. This approach is successfully developed in a number of leading technical universities in the world (Bokov and others, 2013)

In UrFU developed educational programs of bachelor and master training in various fields of engineering in accordance with the CDIO standards. In the learning process introduced project learning in one of the modules of the program. Project-based learning of students is systemic, integrated, consistent and interdisciplinary character. Work on interdisciplinary project is carried out for four to five semesters. High level of the student can be identified by the example of the implementation of 3D-modeling and visualization of the dynamic model of

design object assembly. While working on an interdisciplinary project, students gain an important competence - the ability and skills of teamwork. The distribution of roles in the project team has a clear focus on the individuality of each student. Complex problem for students – the choice of project manager. Management of the project – new and not easy role for them. Preparation of project presentations – another competence, which requires a lot of time. Presentations projects carried out with the assistance of the group curator, representatives issuing department and production.

Conclusion

According to assessments of regional experts, presence competences of graduates of technical universities do not meet the needs of modern production and the problems of economic development. In the first place question is about the poor quality of design competences.

Development of new models of regional engineering education stipulates for the creation of a continuous training system in which project management technologies are used in management system and educational practice.

It has been found out that the mechanism of sustainable reproduction of the new generation of engineering cadres is the project management practice, representing implementation of local projects based on the network partnership, principles of complexity, coherence and complementarity, is a mechanism for sustainable reproduction of a new generation of engineers. To achieve a new level and quality of engineering education and form world-class competencies, they use project learning method based on students' regular involvement in technical and managerial projects of increasing complexity. Design tools used in the development of educational programs, professional standards and certification of professional qualifications.

Improving of project activity and project management can be associated with the enhancement of the design culture of university's teaching staff and introduction of incentive programs. Another perspective direction - the use of methods of optimal design in the creation of the monitoring system implemented educational and infrastructure projects.

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