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## Practice-oriented Educational Technologies in Engineering Universities

# Editorial board

## DEAR READERS!

This issue of the journal "Engineering Education" is devoted to the articles studying best practices of implementing practice-oriented educational technologies in engineering education.

Today it is relevant topic due to intensification of the contradictions between employers requirements and the quality of engineers training and specialists with higher education degree diplomas, prepared to work in engineering positions (bachelors, masters). The study of this contradiction, conducted by the Association of Engineering Education within the last 3-4 years showed that the requirements of employers could be summarized in the need of students able to think and act independently in their professional field from the first working day (without any delay). At the same time Russian academic community is rather conservative and follows training traditions dating back to the Soviet period, when there was so called "Institute of young professionals" that allowed luxury of two or even three years for additional training of graduates to bring them up to the "condition" needed. It was not surprising for university graduate to hear such a phrase when entering the enterprise "Forget everything you've been taught, we will teach you to how to work". Modern employers do not consider it possible to allocate their resources to bring the graduate to the required level and easily justify their claims: "We pay taxes, which make up the budget, including education, please spend it efficiently and stop training half-made professionals at the universities. We do not offer you our half-finished goods and products".

However we could not claim academic community in stubborn wish to preserve outdated system of engineers' training. On the contrary, the new federal state educational standards and CDIO, adopted in many engineering universities in Russia, are enhancing this community to use such educational technologies that would ensure no period of graduates adaptation to work conditions in industries or at least permit to shorten it significantly.

Unfortunately, the current trends in the transformation of engineering education programs (including the content and technology) do not permit us to look forward that changes in the system of engineering training will take place soon.

We are talking about the use of so-called "competence-based" approach. The focus on the competencies formation of engineering university graduates within their training a positive advantage that will improve the quality of their training. However, while maintaining class lesson system of training of future engineers and taking into account explosive bureaucratization process of transition to competence-based education, it seems hard to overcome the mismatch described above.

Developing Learning Methodology Reference. Document Set (commonly known in Russia as UMKD) that meet the bureaucratic rules for the formation of competencies requires a lot of time and efforts from the teacher and its cost effectiveness is very low. We should not forget that this kind of bureaucratic requirements complicate involvement of highly qualified and experienced experts from the industry. The prospect of spending your precious time on the preparation of multi-page documents discourages such experts to participate in the training process. This fact and the fact that university teachers, despite their academic degrees and titles usually have low level of «industrial» qualification, significantly reduce the possibility of formation of those competencies that employers really look for.

In the academic environment it is well known that if great Personality enters the classroom, then UMKD means "nothing", and, on the contrary, if Ignoramus enters the classroom, even well written set of documents will not assist in preparing good professional.

In December 2013 Association for Engineering Education of Russia jointly with Tomsk State University of Control Systems and Radioelectronics, Moscow State Technical University of Radioengineering, Electronics and Automation, Czech Technical University in Prague, European Society for Engineering Education SEFI held in Prague an international conference, which considered in detail the problem of forming the necessary competencies for future engineers. Several papers presented at the conference were submitted to this issue of the journal.

The Editorial Board hopes that presented articles will be helpful for those who choose the tools to develop practical competencies of future engineers. We also hope that these articles will be discussed in professional community and contribute to the emergence of new educational technologies, significantly reducing the period of graduates' adaption to real work conditions.

Sincerely,
Editor-in-Chief,
Prof. Yury Pokholkov

# Contents

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# Forming Competences for Generating New Ideas – Basis of Complex Engineering Education

*Siberian Federal University*
***S.A. Podlesny, A.V. Kozlov***

**The paper examines the structure of modern knowledge, abilities and skills required for generating new ideas. Based on up-to-date approaches, didactic and information technologies have been proposed.**

***Key words:*** *ideas generating, competence, complex preparation, TRIZ, knowledge invention, innovative projects, CAI programs.*

**S.A. Podlesny**

**A.V. Kozlov**

During the progress of engineering education in many world's leading countries, development of problem-based learning (PBL) and project-based learning, as well as other instructional strategies, attention is being increasingly focused on generating innovative ideas. Training creative engineers capable of generating new concepts is the imperative of our time – time of transition to the strategy of innovative development. The worldwide CDIO initiative (Conceive – Design – Implement – Operate), a new approach in engineering education, originally developed at Massachusetts Institute of Technology and actively supported by many leading universities, starts with the "Conceive" stage. In the United States, STEM education (Science, Technology, Engineering, and Mathematics) is being currently turning into STEAM education [1]. A new letter "A" stands for "Arts". It is considered that the arts nurture a creative ability of future engineers to identify and view problems from different perspectives. Those universities which are proved to be «progressive» in this view are actively trying to introduce state-of-the-art Theory of Inventive Problem Solving (TRIZ), originally conceived by Russian scientists G.S. Altshuller and further developed by his followers all over the world [2], instead of simple teaching methods such as "brainstorm", morphological analysis, method of focal objects, syntectics and etc., which are aimed only at developing divergent thinking or some of its elements.

The above-mentioned trends are important to consider when modernizing Russian education system because of the following reasons:

- in accordance with the strategy "Innovative Russia – 2020", creativity is included into the list of competences required for innovative activity, which are developed within the education framework through "modern learning methods and techniques aimed at formation and continuous development of creative thinking skills, motivation, abilities to reveal and formulate problems, as well as to create new concepts that can contribute to problem solving";

- the List of Critical Technologies of the Russian Federation embraces cognitive technologies, i.e. information technologies which are specifically designed to develop intellectual abilities of humans;
- TRIZ originally conceived in the USSR is proved to be one of the most effective theories in the world which is aimed at generating innovative ideas. Most Russian people who share the ideas of this theory grew up in modern Russia and deliver idea generation courses at leading foreign universities.

Deficiencies in forming and developing engineering students' creativity and innovation skills directly influence technological capabilities at the country level: Russia owns 0,4% of worldwide patent applications filed for new inventions (USA – 30%, Japan – 20%, Germany – 10%) [3].

When developing creative thinking skills in engineering students, it is essential to consider that innovation skills and high creativity is a combination of creative, transformational and systems thinking activity which should be based on the peculiarities of interdisciplinary knowledge [4].

The ability to create new ideas is highlighted as an essential characteristic of human activity in terms of sustainable innovation development framework when civilization turns to the fifth and sixth innovation waves.

Developing creativity skills in students is determined by a number of factors:

- innate personal characteristics;
- quality of pre-university education;
- the Mission of the University;
- faculty knowledge and experience in teaching creative skills;
- teaching model (individual learning path, learning in project-based teams);
- launching Elite Education Programs;
- curriculum content;
- teaching tools and techniques;
- adequacy of facilities and computing resources, access to domestic and foreign educational and information resources;
- availability of modeling equipment and systems including simulation software CAI;
- integration level of educational, scientific and engineering activities;
- faculty and student motivation;
- need for innovation in industry, business, and education system.

There are many different techniques which help to generate new ideas. They can be divided into two groups:

1. "Purposeless Search" techniques, historically first to appear, are intended to stimulate human divergent thinking activity, i.e. an unusual and unstereotyped way of thinking. They, for example, include morphological analysis, "brainstorming", method of focal objects (MFO), lateral thinking, "Six Thinking Hats" and etc. [2]. Unlike traditional trial-and-error techniques, these techniques significantly increase the speed of idea generation. However, they can hardly increase the number of ideas effective for solving problems.
2. "Target Search" techniques which are aimed at stimulating not only divergent, but also convergent thinking, i.e. generation of productive ideas effective for solving problems. Synectics has some features in common with target-search techniques, while TRIZ, a theory of inventive problem solving, fully coincides with them [2].

The main postulates of TRIZ can be briefly summarized as follows:

1. Any problem solution is a result of the development of a system. (For example, the invention of the automobile triggered the develop-

ment of "transport" system, the invention of radio – "communication" system, and etc.).

2. In terms of dialectics development results from the struggle of opposites.
3. To solve the problem it is necessary to reveal the contradictions within it and overcome them.

The definite tools (principles, rules, methods, standards, algorithms) to eliminate contradictions derived from the problem have been developed based upon the research and analysis of patents.

Essentially, TRIZ is a philosophy which is not accidently termed as «applied dialectics». According to the recent trends, the meaning of «applied dialectics» has been broadened, implying both non-anthropogenic and social systems. It has been proved that typical models to overcome the contradictions derived from the process itself coincide with TRIZ principles, rules, and standards applied to anthropogenic systems [5]. It allows engineering graduates to «learn from the nature» while acquiring knowledge within Basic Sciences study area.

The comparison of different teaching modes and instruction techniques allows us to classify them based on the level of creativity (Fig. 1) [6]. Traditional lecture-seminar teaching mode corresponds to the 1st level, with best examples of innovative teaching being at the 2nd and 3rd levels. Problem-based learning which is being actively introduced at foreign universities can be referred to the 2nd and 3rd levels, as well. "Purposeless Search" techniques can be applied at the first three levels. Innovative education system TRIZ-pedagogics [7] corresponds to the 4th level and allows integrating TRIZ principles into other disciplines, design activity and scientific work. As a part of TRIZ-pedagogics there was a method of creative tasks which could be solved applying not only definite knowledge, but TRIZ principles, as well.

Siberian Federal University is actively involved in the development of innovative education system "TRIZ-pedagogics". It offers such courses as "Principles of Scientific Research", "Fundamentals of Technical Creativity", "Innovation Studies" and etc., which outline the methods that help to be effective at problem-solving, include the exercises aimed at developing creative skills and provide recommendations on filing patent application. The experts from UNESCO Centre "New Materials and Technology" have been working on knowledge invention method and the method of innovative projects since 2000 [8]. Due to their hard work, "TRIZ-pedagogics" is gradually becoming an educational system which can be applied at different stages of education process.

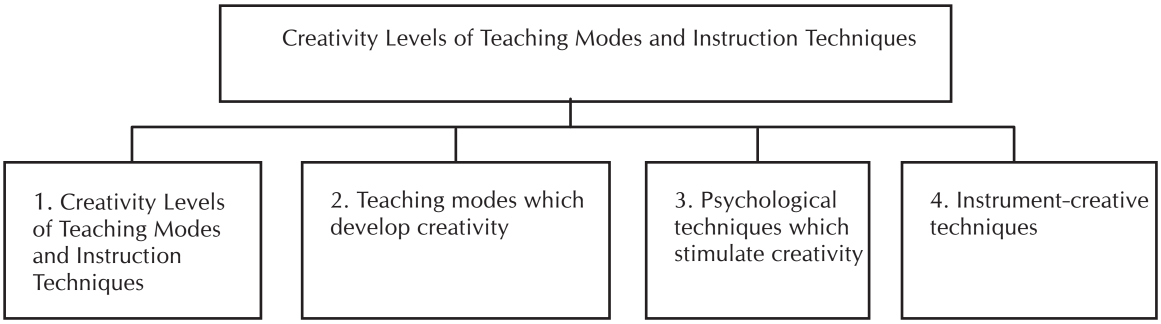
The method of knowledge invention allows incorporating innovative ideas into a body of existing knowledge, which in its turn develops corresponding skills and abilities in class and presents new material in terms of practice and experience. This method fully explains and confirms the idea of many scientists and educators who insist on the necessity of turning from traditional learning to "active knowledge acquisition". Evolution of any system studied within any education program is regarded as a result of solving contradictions in the system-predecessor, which create barriers for further evolution. It is this result that is "reinvented" by students by using TRIZ methodology, principles and standards.

The method of innovative projects is a combination of problem-based learning and project-based learning with TRIZ methodology. Problem-based learning stimulates student's interest in curricular subject matter, deepens their understanding of the material. However, students being only psychologically motivated to take charge of problem solving are not provided with the corresponding cognitive "instruments". Therefore, educators often have to give their students ready solutions. For the

ENGINEERING EDUCATION 13'2013



**Fig. 1. Teaching Mode Classification Based on Creativity Levels**




same reason, the projects which are created within project-based learning are not often innovative. TRIZ significantly improves a student's ability to solve problems given by a teacher and contributes to developing the projects which are really aimed at solving serious engineering problems.

Information technologies play a significant role in training creative engineers. It is a world-wide trend to apply product lifecycle management (PLM) to design and production of high technology products based on the information technologies. The main components of PLM are as follows: product data management (PDM), collaborative product development (CPD), computer-assisted design (CAD), computer-aided engineering (CAE), manufacturing process management (MPM). Modern CAD-systems are based on the technologies of parametric design, i.e. optimal choice of numerical parameters of an item without changing its structure and operation mode. Innovations, as a rule, involve the development of a radically new structure. Therefore, it is essential to combine PLM standards with new-class programs – CAI (Computer Aided Invention) – which are becoming increasingly common.

There are CAI programs which are based on the methods of possibility enumeration, for example "Brainstormer" that features brainstorming process. "Invention Machine", the first CAI program, was developed by a group of specialists from different republics of the Soviet Union in accordance with the TRIZ principles. During the period of socio-economic restructuring («perestroika»), when there was a significant decline in demand for any type of inventions, most of these specialists went abroad, specifically to the United States and established Invention Machine Corporation Company. The company produced new English versions of Invention Machine with the significant financial support of such companies as Motorola, Intel and etc. Other companies which were also established by soviet specialists designed such programs as "Tri-Solver" and "Innovation Work Bench". Today, Invention Machine Corporation offers "Tech Optimizer" and "Goldfire Innovator", an optimal decision engine. These programs are in great demand among transnational corporations and universities which train specialists for such corporations. It is obvious that knowledge of PLM standards and CAI software is essential for student future professional career.

The algorithm of forming the structure of modern knowledge and abilities required to develop corresponding skills for generating and implementing new ideas is presented in Fig. 2. All three types of thinking (Fig. 2) comprise innovative thinking.

However, all above-mentioned components can be affective at developing creative thinking skills only in a case of interconnection between them. Even fundamental courses which are delivered during the first years of education should be based on the method of knowledge invention and principles of applied dialectics. To make this process even more effective, it is better to apply these methods for pre-university education. Besides, it is important not only to reveal the existing demand for inventions, but also to influence the demand itself. Practical skills are developed in class alongside the acquisition of corresponding information technologies when the existing body of knowledge is «reinvented» for further application in scientific work and project activity.

An engineer capable of generating and implementing new ideas is a key figure of innovation-driven economy. Russian system of engineering education has an important competitive advantage over corresponding foreign systems as it has significant resource for further improvement – refining the methodology for developing idea-generation skills. The serious task to solve is to apply this resource effectively.

ENGINEERING EDUCATION 13'2013

**Fig. 2. Algorithm of Competence Formation Required for New Idea Generation and Implementation**

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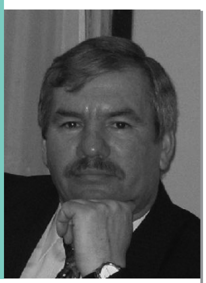
UDC 378

# “Formula-Student” Project as a Platform for Practice-Oriented Training of Enginnering Graduates

*Togliatti State University*
***V.V. Yeltsov, A.V. Skripachev***

**Practice-oriented training, an innovative teaching technology, is one of the conditions for quality assurance in Higher Education. Such innovative international “Formula-Student” project, combining education, science and sport, is being implemented at Togliatti State University.**

***Key words:*** *educational program, “Formula-Student” project, curricular module, learning outcomes, engineering activity, employer.*



**V.V. Yeltsov**

**A.V. *Skripachev***

One of the criteria of innovative approach to managing education process at universities is particular attention to developing engineering thinking by incorporating peculiar methods and engineering issues into various programs. In accordance with this criterion, university should strive to train such engineers who will be able to work in any sphere of human activity – engineering, humanitarian, scientific, and pedagogical. Besides, an “engineer” is defined as one who is capable of identifying and solving complex problems, knowledgeable of existing constructions, is capable of designing new products and technologies, managing processes and creating self-improvement strategies.

Training such engineers who can be qualified as a “born and bred engineer”, a creative specialist, can only be achieved through the application of innovative practice-oriented teaching technology instead of traditional teaching and learning techniques. Practice-oriented education implies that students have opportunities to be engaged in a diversity of practice-related experiences within their discipline areas. The basic principle of such education is “Docendo discimus” (Latin) - the idea that “We learn from teaching”. In other words, teachers and students work together producing a real product which can be of practical and commercial value both for university and a potential employer.

Practice-oriented training ensures the quality and relevance of education and stimulates the interest of different participants in the process itself:

- university benefits from image improvement, employers’ investments and the expansion of existing partnerships;
- graduating departments gain advantages of new internship and job placement opportunities, strengthening relationships with professional communities, making commercial contracts;
- faculty members have not only financial benefits, but also gain advantages of developing new methodological guidance and expanding the scope of professional activity;
- students are encouraged by a better opportunity for well-paid jobs, including executive positions, financial benefits and cooperation with analogue student teams from other universities.

International "Formula-student" project which combines learning objectives, scientific work and sport, is one of the most innovative and promising projects implemented at Togliatti State University.

Today, International "Formula-student" is the best project of its kind in Europe, the United States, and Australia. Also, it is becoming more and more popular in Russia. Initiated by the Society of Automotive Engineers (SAE) in 1998, it stimulates student engineering work and inspires them to conceive, design and fabricate a small single-seat racing car with further participation in racing competitions. The idea is that students with different education background must not only design, build and develop a product as a team, but also solve problems concerning marketing, advertising, logistics, economy and other issues related to the project implementation. Thus, it can be stated that the project contributes not only to growing talented engineers, but also developing other professional skills related to various spheres of human activity. The project provides students with a real practice in design, manufacture and business issues of automotive engineering. It helps them to gain experience and develop corresponding skills to become "handy" engineers who have deep understanding of different factors affecting the final product – qualitative characteristics, cost, safety, reliability and etc. – and are able to apply this knowledge in competitive tournament in order to achieve best results. It teaches them all about team work, under pressure and to tight timescales. Participation in "Formula-student" project demands total commitment, lots of work even at late nights and weekends. Besides, students are not free from many frustrations and challenges along the way and sometimes they have to do again what has been already done but it is this fact that contributes to the development of highly talented young engineers.

Another advantage of this project is that being implemented at university level it also stimulates the interest of pupils in various engineering disciplines. It is not a secret that engineering jobs are not so popular in Russia. That's why for most engineering programs, enrolment competition for state-funded places is not very high. The "Formula-student" project, particularly single-seat racing car designed and fabricated by students themselves to participate in a real racing competition makes an effective striking picture (Fig.1) and can encourage school-leavers to pursue engineering courses and careers.

The concept of the project is the following: during an academic year, students must organize a team themselves, share their responsibilities, find sponsors and draw up a business plan, design and, finally, fabricate a racing car which is presented to a panel of leading engineers and PR-managers. The cars are judged in a series of static and dynamic tests, as well as during final racing competition.

### Understanding how International "Formula-student" project is incorporated into education framework at TSU

The first three stages of the project are incorporated into educational process itself while the fourth one is made as a sport team completion, i.e. extra-class activity.

**First stage** – the objective of the first stage is to provide students with contemporary engineering knowledge and develop corresponding professional competences by incorporating new teaching and learning technologies, among which are practice-oriented training, stimulation of student scientific work, project-based training and team work. Students are taught the fundamentals of the different educational programs in accordance with specially developed modules incorporated into course curricula.

A module is a part of a course or discipline which is aimed at developing a definite competence or particular ability important to student future career prospects. The achievement of the module learning outcomes, including acquisition of theoretical knowledge and practical skills is always controlled at the end of the module.

Each module has a definite load (in credits or hours), as well as the list of "entry" requirements a student must meet before enrolling in this module and the list of learning outcomes a students must achieve at the end of the module. "Entry" requirements specify students' level of knowledge, abilities and skills required for

ENGINEERING
EDUCATION
13'2013



**Fig.1. Racing Car Fabricated by TSU Students within International "Formula-student" Project**



successful module completion. Module learning outcomes include detailed description of the competences a student must acquire at the end of the module. Modules are not strictly sequenced and are not always referred to a definite discipline within an educational program. In this respect, each module represents an independent unit. At the same time, any module can be easily incorporated in program curriculum if it corresponds to program objectives and learning outcomes.

In addition, module includes the requirements to teaching resources, teaching faculty and facilities, which ensures quality of education. Modules are developed as separate units which are not connected with the existing educational programs. Thus, each module can be incorporated into several educational programs.

As a rule, module consists of following components:

- clearly defined objective;
- clearly defined module learning outcomes (set of competences, knowledge and skills);
- resource section – structured theoretical material, study guides and training simulators, training software, and various databases;
- practice section – a set of typical, complex problems, cases and exercises with solution algorithms;
- assessment section – set of assignments developed in accordance with module objectives, which include placement and final tests, special problems of different difficulty levels and assessment guidelines.

The example of "Formula-Student" modules with regard to the objectives and engineering problems to be solved during the project is given in Table 1.

"Formula-Student" project modules (FS module) incorporated into educational programs comprise a special teaching technology which falls within the purview of copyright law. This teaching technology is characterized by a number of peculiarities and principles to be considered when being incorporated into education process. As these modules are parts of common Bachelor's and Master's Degrees programs, most students pursuing engineering degrees should have a possibility to take them. However, it does not mean that lecturing is the only teaching method to be used.

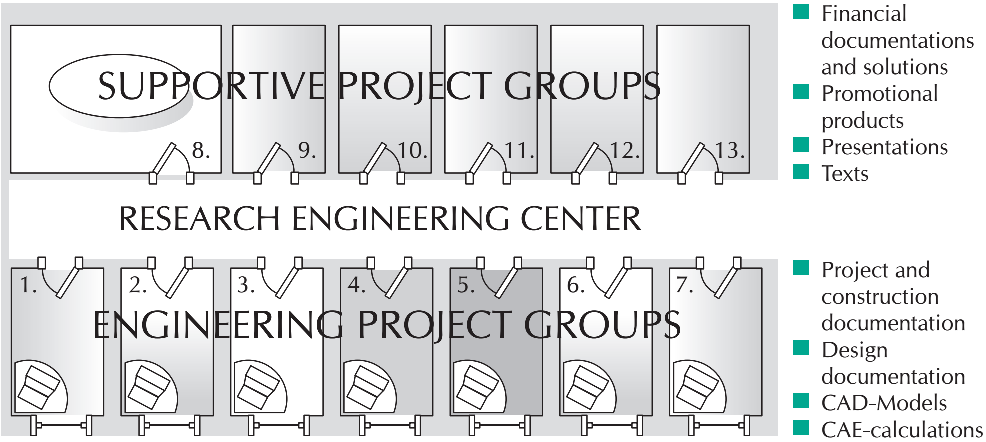
The structure and content of a FS module is defined by the characteristics of teaching technology which contains maximum amount of student independent work and minimum number of class hours. To ensure effective use of the technology, TSU has launched a special education portal which provides students with resources for independent work, access to teaching materials and study flowchart.

Thus, these modules can also be applied within distance learning programs (e-learning technology when interaction

**Table 1.**

| Project Group Objectives | FS Modules | Degree Programs Relevant to FS Modules | Courses Relevant to FS Modules |
|---|---|---|---|
| Analogue examination and selection of internal-combustion engine design | Collect and interpret data on internal-combustion engines | 141100.62 Power plant engineering<br><br>141100.68 Reciprocating and combined engines | - Protection of intellectual property<br>- Configuration and operation mode of internal-combustion engines |
| Collect and interpret data on internal-combustion engines | | | |
| 3D-modeling of internal-combustion engines (CAD) | 3D CAD-modeling of internal-combustion engines | | - Building of internal-combustion engines<br>- Engine systems<br>- Computer graphics<br>- CAD fundamentals |
| | | 150700.62 Machine Building. Specializations Mechanical Engineering Technology", "Machines and Fabricating Technology" | - CAD fundamentals |
| Engine assembling | Internal-combustion engine assembling | 141100.68 Reciprocating and combined engines | - Internship<br>- Process-layout preparation |
| Collect and interpret data, analogue examination and selection of principle unit construction | Collect and interpret data on transmission | 190109.65 Land Transport Vehicles and Tractors<br><br>190100.62 Land Transport Technological Complexes | - Patenting<br>- Configuration of vehicles and tractors |
| | | | - Vehicle design<br>- Process-layout preparation<br>- Self-organization fundamentals |
| Component and final transmission assembling | Transmission assembling | | - Internship<br>- Configuration of vehicles and tractors |
| 3D-modeling of transmission (CAD) | 3D CAD-modeling of transmission | | - CAD principles in building vehicles and tractors;<br>- vehicle engineering design<br>- computer graphics |
| | | 150700.62 Machine Building. Specializations "Mechanical Engineering Technology", "Machines and Fabricating Technology" | - CAD Fundamentals |

**Fig. 2. Layout and Results of «Research Engineering Center» within "Formula-student" Project**






of a student with the author of a module is computer mediated).

As FS modules are designed to enable learners to acquire necessary professional experience, they involve maximum number of active teaching technologies, i.e. simulators, imitation games, role games, seminars, case studies, master-classes, individual and group work.

**Second stage** implies application of the theoretical knowledge obtained at the first stage including computer-aided structural design of automobiles, technology development, market research of value engineering and feasibility studies, application of PR-technologies, and etc. Students work under the supervision of a skillful engineer or faculty member who has experience in design work as a member of "Research Engineering Center" initiated by "Formula-student" teams. The role and responsibilities for team members, including team supervisor, are clearly set and involve drawing up plans and graphics of all current and further works. A student team is divided into the separate groups based on functional responsibilities (Fig.2).

**The groups of «Formula-student» project team.**

1 Internal-combustion engines.
2 Transmission and running gear.
3 Carroserries, basic structures, interior.
4 Electric accessoires.
5 Configuration and design.
6 Process-layout preparation.
7 Engineering calculations (CAD,CAM,CAE).
8 Full-scale tests.
9 PR-management.
10 Economics and Finance.
11 Art and design.
12 Journalism.
13 Foreign language.

**Third stage** involves students working on manufacturing a racing car according to their design, drawings and technologies developed in a special work room which is equipped with all necessary instruments and tools. Here students work together with professional engineers and technicians under supervision of both the team leader (student) and the project supervisor. Production area (Fig.3) is divided into several different sites based on the kind of work.

All stages are supervised by a project supervisor who must hold a position of department head or be a member of research-and-development center.

**The final stage** involves such extra-curricular activities as static and dynamic tests of the fabricated car and final racing competition. Static tests include "Project Presentation and Defense", "Presentation", "Cost Event".

The purpose of "Project Presentation and Defense" is outlined in SAE rules and regulations as: "The objective of the presentation event is to evaluate the team's ability to develop and deliver a compre-

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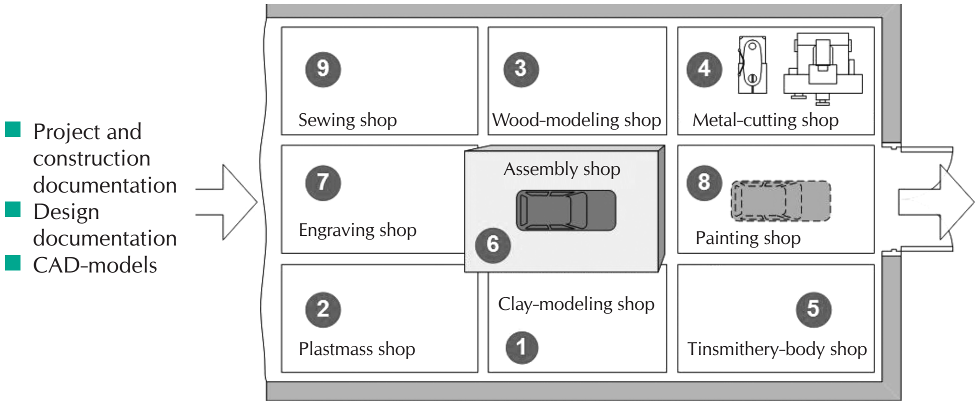
**Fig. 3. Producaion Area Layout**




hensive business case that will convince the executives of a corporation that the team's design best meets the demands of the market".

The presentation must logically cover all factors which can influence the competitive capability and viability of a business model. Teams should make presentation with a view to obtaining a business deal to manufacture the team's car. To intensify the effect, it is essential to demonstrate technical features of the proposed car.

The main objective of «Cost Event» is to prepare cost report including accurate vehicle cost estimates at low sales volume, which is to be sent to the Cost Judges prior to the competition.

Dynamic tests involve "Acceleration Test", "Figure of 8", "Sprint", "Endurance Test", "Fuel Economy Test". All dynamic tests are carried out at a special site with witness of judges and great amount of spectators. This very fact emphasizes one of the objectives of the project – to stimulate the interest of young people in various engineering degree programs offered by TSU.

## Conclusion

Management of international "Formula-Student" project presents a great number of challenges to students, faculty members and university administration. One of the basic peculiarities of the project is that it stimulates motivation to improve education quality not only of students but of faculty members, as well. It is explained by the fact that students, being motivated to achieve the best results, strive to gain deep practical knowledge in engineering problem solving, as well as to understand innovative methods and technologies applied in engineering work and management. Thus, the project helps both students and faculty members to enhance their professional attributes, which in its turn significantly contributes to improving education in general.



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UDC 378

# Practical Competences as Learning Outcomes Using CES EduPack

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**The quality of modern engineering education is measured in terms of learning outcomes. This holds true for, e.g., the ABET accreditation system and the CDIO Syllabus. This paper demonstrates how a computer-based teaching resource, CES EduPack, could be used by Universities towards learning outcomes necessary for accreditation of engineering programmes.**

***Key words:*** *learning outcomes, engineering education, assessment criteria, accreditation.*

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## Introduction

Quality assurance is an essential aspect of modern engineering education. In this context, learning outcomes are important. Learning could be defined as what the student can demonstrate that they know; desired learning outcomes can be used to specify and evaluate courses and programmes. This is central to the Bologna process of the European Higher Education Area and also to major accreditation systems for higher education. In this paper we examine how a computer-based teaching resource, CES EduPack [1], can contribute to the CDIO Syllabus 2.0 [2, 3], which offers a set of learning outcomes with particular emphasis on practical competences. Many of the findings can be extended to accreditation systems, such as ABET or EUR-ACE.

This paper addresses five areas of CDIO Syllabus 2.0. These are, at the second level of detail: 1.3 Advanced Engineering Fundamental Knowledge, Methods and Tools; 2.1 Analytical Reasoning and Problem Solving; 2.3 System Thinking; 4.1 External, Societal and Environmental Context and 4.4 Designing. The authors give three examples of how CES EduPack and associated teaching resources can support educators in achieving learning outcomes in these areas.

## Learning Outcomes

Within an outcome-based educational framework, teaching/learning activities (content, methods etc.) should be aligned with the intended learning outcomes and with the assessment of these, see Fig. 1 [2, 4].

It is helpful to group learning outcomes into three categories: (I) Knowledge and understanding, (II) Skills and abilities, and (III) Values and attitudes. We interpret learning outcomes associated with knowledge as the capability to use information correctly. Understanding requires the ability to use this knowledge in new and unfamiliar situations and the ability to create new knowledge. Skills and abilities are sometimes referred to as practical knowledge. Finally, Values and attitudes reflect the ability to use knowledge and understanding responsibly.

Teaching resources to support outcome-based teaching can be designed to contribute to all three of these categories. CES EduPack has been developed with this in mind. It supports a methodology that links the selection of materials with the design process. In this paper, the outcomes discussed are mainly associated with practical competences (such as skills), which are primarily acquired with adequate interaction between the students, the teacher, and the software/resources.

CES EduPack is a high-quality source of information for materials and processes. CES EduPack introduces students to ideas of eco-design and of eco-audits (fast, approximate life cycle inventories). Moreover, it supports the teaching of sustainable development, providing access to information about the economies, environmental behaviour, social provision and governance of the nations of the world – the nations from which materials are sourced.

It must be emphasized, however, that the information contained in databases, such as those of CES EduPack, cannot alone generate learning outcomes in higher education. It is how the teacher and students use information (in a critical manner) – that is important. This aspect is supported by a number of additional teaching resources, within the software as well as in several textbooks to provide a detailed explanation and depth in the topics of mechanical design [5, 6] and environment/sustainability [7]. Furthermore, a range of White Papers and exercises are available to the teachers on specialized topics [8], such as: Teaching Engineering Materials, Materials and Product Design, Eco Design, or Materials and Sustainable Development. Users [9, 10] have found CES EduPack to be helpful in gaining ABET accreditation of programmes and have written about their experiences in using CES EduPack and how it supports various learning outcomes. These examples are outlined further.

### Examples in teaching

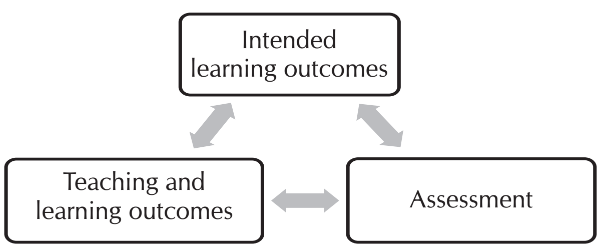
The software is particularly well adapted for use in applied engineering projects, such as product development or capstone courses. Since CES EduPack is an advanced engineering teaching tool, implementing sophisticated methods for materials selection, most courses using the software adequately would be able to contribute to learning outcome 1.3 Advanced Engineering Fundamental Knowledge, Methods and Tools. Therefore the examples below focus on other four learning outcomes (see Fig. 2).

### Example 1: Mechanical Design

CES EduPack enables the selection of materials and manufacturing processes during engineering design. This approach, developed at the Engineering Department of Cambridge University [1, 6, 7], uses a rational, systematic approach that starts with the design objectives (minimizing weight, for example, or minimizing cost) and design constraints (the mechanical, thermal, electrical or durability requirements set by the design brief). The methodology is clearly laid out with numerous worked examples and suggestions for projects provided.

A specific example is provided by Professor Eason of the University of North Florida [9] where CES EduPack has been used in Senior Capstone design projects (EML 4551&2) for some

**Fig. 1. The Concept of Constructive Alignment Used by Biggs [4]**



years. Students, working in pairs, were tasked with re-designing and building a mountain bike. They needed to understand the requirements and translate these in to constraints and objectives in order to use the selection tools available in CES EduPack to select frame-materials that meet real-life specifications for the bike. They could easily factor in different design priorities and review how that changed the selection, while playing out different scenarios in the software, including consideration of conflicting objectives and trade-offs decisions in a design process.

The criteria of high strength, low density, acceptable cost and low carbon footprint, was straightforwardly implemented with the graphical selection facility of the software (Fig. 3). This led to a number of possible choices, among them the possibility of a bamboo-framed bike, which the students successfully built and tested. This example of a Design-Build course, including elements of testing, modelling and a teamwork shows how CES EduPack can contribute to CDIO outcomes point 4.4 Designing, 2.1 Analytical Reasoning and Problem Solving and 2.3. System Thinking.

### Example 2: Eco Audit Tool

Responsible engineering design, today, should include an analysis of the environmental impact of the proposed design. The eco audit tool of CES EduPack allows rapid, approximate, life cycle assessments. The model used in the Eco Audit Tool is purposefully simple and explicitly explained in the help menu, so that students can engage with, discuss and disagree with the model, as well as its output. Data used on life-cycle assessment projects is notoriously weaker than the mechanical property data that engineering students are used to.

Therefore, this is highlighted, both in the help menu and the suggested exercises, so that students can learn to deal with uncertainty. This means that projects where students use the Eco Audit Tool are particularly useful in supporting learning outcomes 2.1 Analytical Reasoning and Problem Solving and 2.3. System Thinking.

A course on Materials Selection for Mechanical Design (EMA 4507), also from the University of North Florida [9, 12], uses this tool to reverse engineer a Smartphone. The structures and materials of the phone were analysed by two teams one tasked with maximizing mechanical robustness, the other tasked with minimizing embodied energy and carbon footprint. Eco Audit was mandatory for both teams.

Further, a general graphical output of CES EduPack (Fig. 4) illustrates a comparison of the embodied energy of two alternative designs. The "What if..." facility allows immediate feedback on the consequences of any change of material in the product.

**Fig. 2. Learning Outcomes Aided by EduPack, in Relation to CDIO 2.0**

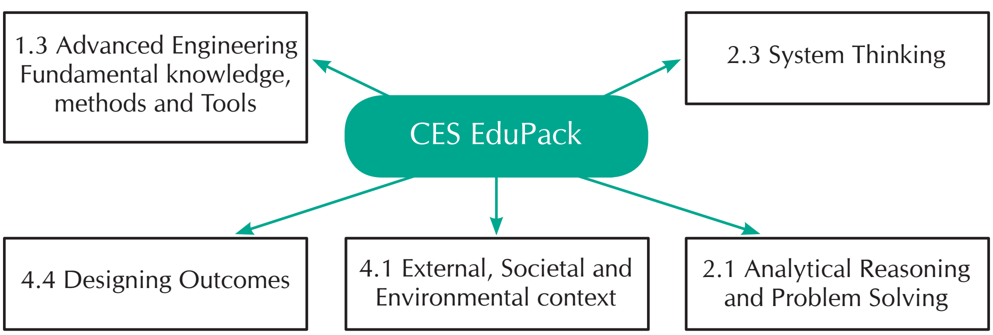


**Fig. 3. Materials Chart Comparing Bamboo with Other Frame Materials [9]**

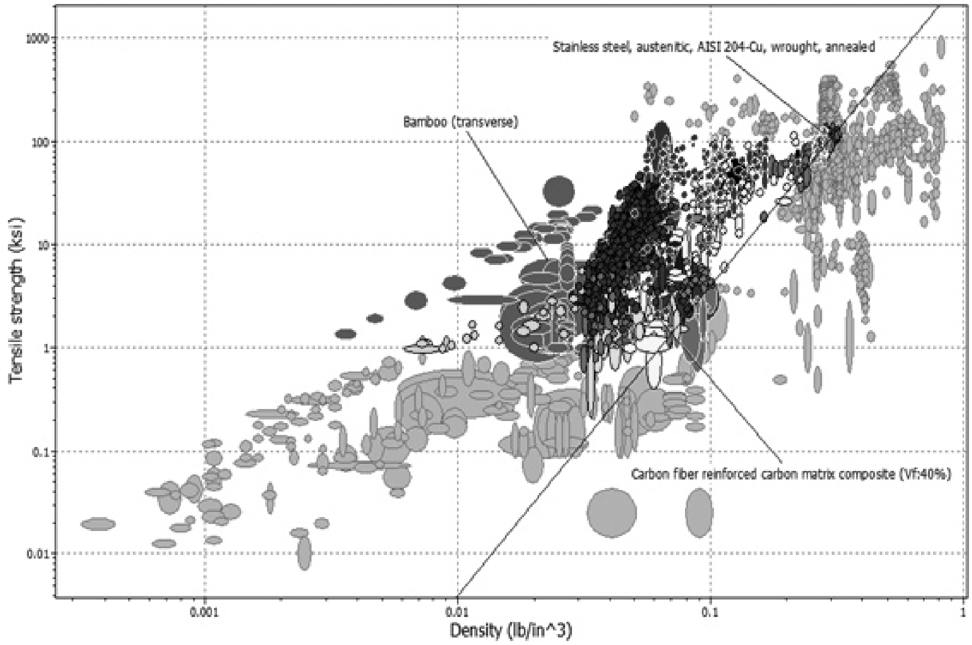



**Fig. 4. Eco Audit tool can be used for re-engineering and exploration**

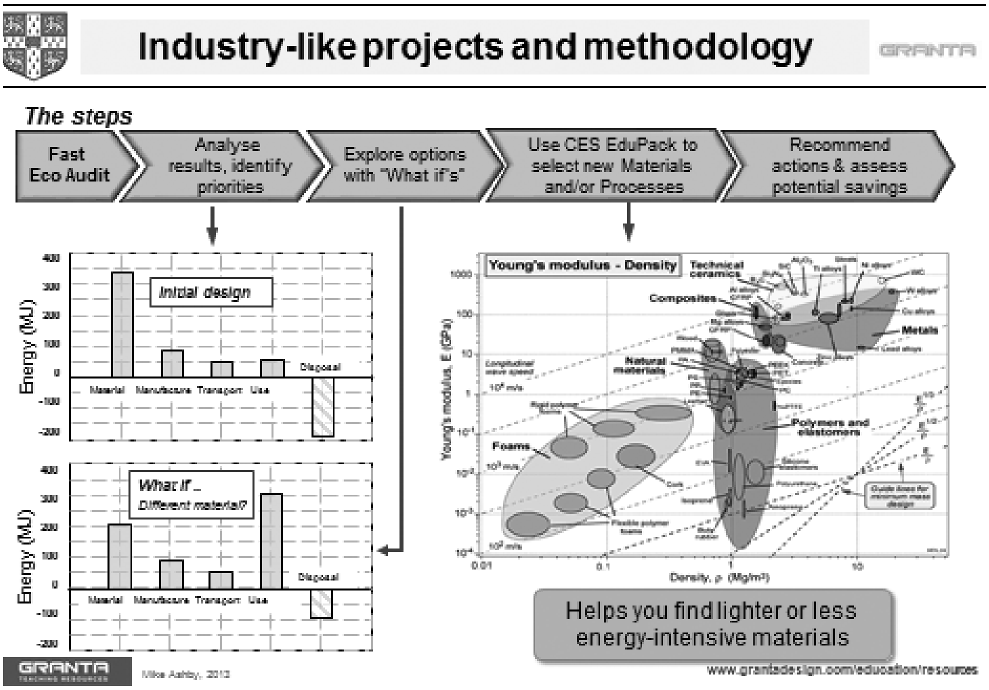
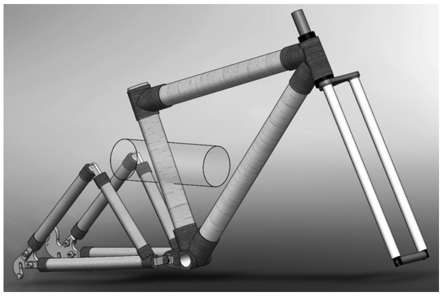
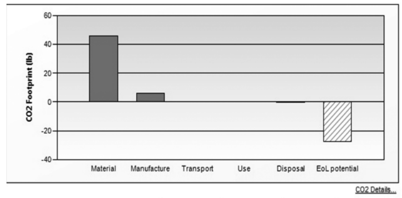


**Fig. 5. CAD Image and Eco Audit for Bamboo Mountain bike [9]**






| Phase | Energy (kcal) | Energy (%) | CO2 (lb) | CO2 (%) |
|---|---|---|---|---|
| Material | 8.63e+04 | 90.6 | 45.6 | 88.1 |
| Manufacture | 8.38e+03 | 8.8 | 5.8 | 11.2 |
| Transport | 0 | 0.0 | 0 | 0.0 |
| Use | 0 | 0.0 | 0 | 0.0 |
| Disposal | 548 | 0.6 | 0.354 | 0.7 |
| Total (for first life) | 9.52e+04 | 100 | 51.8 | 100 |
| End of life potential | -5.23e+04 | | -27.7 | |

The case of the Bamboo bicycle, mentioned in the previous example, was also subject to an Eco Audit (Fig. 5) and compared to a traditional metal bike.

### Example 3: Sustainability Analysis

The Sustainability Database and supporting methods of CES EduPack guide students through a broad study of the supply-chain of engineering materials, background information on ethical sourcing and manufacture, and awareness of business risks, associated with materials and with the legislation that now controls materials' use and their disposal. The Sustainability Database includes access to data on economic, social and environmental performance of 210 nations. The method was tested in Universities from Cambridge (UK), Urbana (USA) and Barcelona (Spain). The five-step methodology (see Fig. 6) includes: setting-up objectives, identification of stakeholders, fact-finding, integration and reflection. A case from Professor Ferrer-Balas of Universitat politecnica de Catalunya in Barcelona [11] provided feedback on use of the Sustainability Database and CES EduPack (The main outcomes of the project have been presented elsewhere [11]). The aim of the exercise was to analyse bamboo as a construction material in Mexico. Students improved their understanding of the case, concluding that just two dimensions – natural and recyclable were too simplistic. The concepts of Human, Natural and Manufactured Capitals were used to represent diverse contributions of materials/technology to environmental and social aspects.

The intended learning outcomes for students of the course using CES EduPack sustainability database and the described method are summarized and classified, according to the CDIO syllabus, in Table 1.

Wider issues, such as market availability, regulations, capacity, social acceptance, costs, were analysed while having access to reliable traceable and coherent data sets in the database. The debate about sustainable creden-

**Fig. 6. Five-step methodology for analysis of sustainable development**

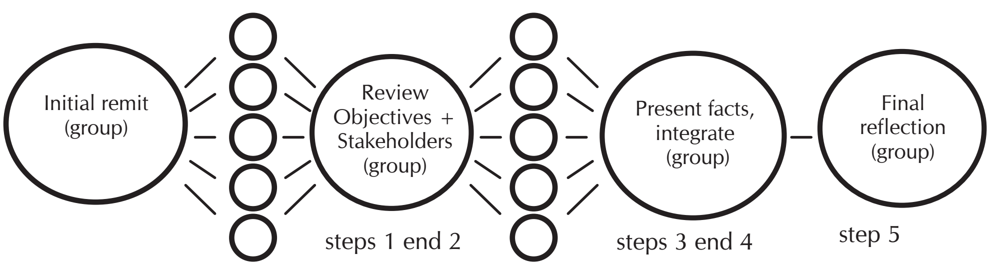


**Table 1. Sustainability Design Course Learning Outcomes (self-assessed) [11]**

| | Learning Outcomes (LO) | LO vs the levels of Knowledge, Skills and Attitudes [Based on Bloom's and Krathwohl's taxonomy] | | | | | | LO vs the most frequent accreditation standards | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | By the time the students finish the course, they should be able to ... | Knowledge | Comprehension | Application & analysis | Synthesis, creativity and evaluation | Receiving, responding and valuing | Compare, relate and synthesis | Standard | | |
| | | Knowledge | | Skills | | Attitudes & values | | EUR-ACE | ABET | CDIO |
| 1 | Know and understand the basic dimensions of the sustainability concept through the capitals approach | ● | ● | | | ● | | 1.2<br>1.4 | a, j | 1.2 |
| 2 | Understand the complexity of sustainable technology development due the different cometing articulations and be development due the different cometing articulations and be capable of explaining it with examples | ● | ● | | | ● | | 1.5<br>5.5<br>5.7 | f, h | 2.3<br>4.1 |
| 3 | Conduct a systemic sustainability analysis in a four step methodology | | | ● | | ● | ● | 2.2<br>2.4 | b, k | 2.2<br>2.3 |
| 4 | Integrate multidisciplinary information regarding one problem | | | ● | ● | ● | ● | 5.5 | e | 2.1 |
| 5 | Identify stakeholders regarding a controversial socio-technical issue and identify their perspectives on a specific issue | | | ● | | ● | ● | 5.4 | J | 4.1 |
| 6 | Find contrasted information in databases (in particular SUSTAIN), internet, etc., about materials, technology, states, legislation related to a project. | | | ● | | ● | | 4.1<br>4.4<br>4.6 | b | 2.2 |
| 7 | Plot diagrams with the SUSTAIN database and present information to a specific audience. | | | | | ● | | 6.2 | g | 3.2 |
| 8 | Work in teams in a specific project | | | ● | ● | ● | ● | 6.1 | d | 3.1 |
| 9 | Evaluate options for sustainable technology developments | | | | | ● | ● | 6.4 | h | 2.3<br>2.4 |

tials of materials prepares students for industry-related questions, challenges and opportunities, including the roles of stakeholder analysis and relevant legislation. This example demonstrates facilitation of outcomes 4.1 External, Societal and Environmental context and 2.3. System Thinking.

## Conclusions

Used appropriately in relevant activities, CES EduPack is well aligned with learning outcomes under 1.3, 2.1, 2.3, 4.1 and 4.4 of CDIO Syllabus 2.0.

Since CES EduPack is an advanced engineering tool, one used both by industry and in research, it is able to contribute to learning outcome 1.3 Advanced Engineering Fundamental Knowledge, Methods and Tools. Built-in science notes, explicit details about models used and data sources, and warnings about uncertainties, facilitate interactive, critical use inside or outside the classroom. This leads to better Analytical Reasoning and Problem solving, 2.1.

CES EduPack is predominately used in a system context (e.g. a product, a production system or the world). Trade-offs within a system with regard to material selection, Eco Audits and Sustainable Development project work, help students to gain skills outlined in 2.3 System Thinking. The Eco Audit Tool and the Sustainability Database of the software provide unique support for the analysis of sustainability of products and technologies, with students encouraged to consider different stakeholder perspectives, as in 4.1 External, Societal and Environmental Context.

CES EduPack was originally created to support teaching related to mechanical design, although it has broadened its remit significantly. The design process and the ways in which material and process selection fits in to that, are described in detail in many books, supporting exercises and white papers, thus contributing to 4.4 Designing.

The CES EduPack supports an active, creative and practical learning approach, helping students in complex multidisciplinary issues. Provided supportive guidance of a teacher, it helps to prepare students for professional challenges in industry.

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# “Risk-Management” and “Risk of Management” as Phenomenon of Continuing Professional Education

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**The paper examines the concept “challenging professional environment” as an obligatory component of continuing professional education, analyzes the risks inherent in workplace-related and person-related sub-systems as a special group of risks in professional micro environment, and outlines the concepts “risk-management” and “risk of management” which constitute the conceptual basis of continuing professional education programs.**

***Key words:*** *professional environment, embarrassing professional environment, “risk-management” and “risk of management”, educational programs of supplementary professional education.*

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As continuing professional education performs the compensatory and foreseen functions for specialists, it contributes significantly to developing the human resources of the next generation. The above-mentioned functions cause individuals «to eliminate lacunae in basic professional education, improving theoretical knowledge, skills and experience, ... as well as to develop the ability to foresee potential technical challenges, design the advanced solutions and consider their possible consequences» [4, p. 288-289].

What are the factors and conditions that objectify the compensatory and foreseen functions of education? In our opinion, the content of vocational and higher professional education is basically intended to place graduates in professional context as quickly as possible, develop only those professional skills and abilities which are restricted by social demand and resources. An employee can only perceive absolutely new and never-before-comprehended professional activities when acquiring corresponding professional experience and skills. At this moment, definite manufacturing situations which have never been analyzed before within any professional competence are thoroughly examined. Thus, challenging professional environment stimulates the compensatory and foreseen functions of education and, therefore, it should be considered as an obligatory component of continuing professional education programs.

The challenging professional environment is a set of difficult workplace-related situations organized in a hierarchical way according to the degree of threats and hazards inherent in them. In view of the fact that there are a great number of different classifications and typologies of difficult workplace-related situations, which have been developed in psychology, conflict management, and labor psychology, it is more logical to explain the hierarchy of challenging professional environment challenges in terms of two phenomena: firstly, "professional environment", i.e. its components and the relationships between them; secondly, "danger in problem solving" as a basis for the classification of challenging professional environment challenges.

A.K. Markova defines professional environment as "a complex of workplace-related and person-related working conditions. The sub-system of workplace-related conditions involves the subject of labor itself, labor instruments, procedures and operations, as well as the hierarchical relationships imposed from the outside. The sub-system of person-related conditions includes interpersonal relationships, self-perception and the capability of employees to look at labor from different perspectives" [3, p. 104]. Those difficult workplace-related situations which are characterized by the absence of correspondence between position requirements, an employee's capabilities and working conditions are classified as problematic, critical (emergency) and extreme [1, p. 211]. Risk situations (potentially hazardous situations) build up a special group. As the influence of uncertainty factors is an essential attribute of any difficult situation, risk situations can be encountered at all levels of danger (obstacles in problem solving). It is our opinion that the risks inherent in workplace-related and person-related sub-systems of professional environment (risk associated with uncertainty and/or presence of labor subject, instruments and procedures; risks associated with standards and quality of operating procedures; risk of effort-reward imbalance, and etc.) comprise a special group of risks attributed to professional micro environment. It is this group of risks that is incorporated into the concept "risk-management". The combination of such words as "management" and "risk" embraces "strategies, processes, people, procedures and tools for evaluating and managing uncertainty factors encountered by a company in the process of value creation" [2, p.15]. The emergence of a new profession, i.e. a risk-manager, has enriched professional community and stimulated social demand in the development of the corresponding education programs.

In response to the needs of executive staff, continuing professional education has developed a wide range of flexible, intensive and short-term courses intended to develop culture of risk management. These education programs are based on the concept "risk of management" which embraces the focused management activities and procedures, as well as preventive measures for management mistakes. These mistakes are commonly caused by the risks associated with goal-setting, forecasting, planning, stimulation, control and assessment, i.e. all stages of management as a process which involves the control of human factor in order to increase the performance and efficiency of employees.

The concepts "risk-management" and "risk of management" constitute the basis of continuing professional education programs: the former is relevant to Bachelor's and Master's Degree programs in Risk Management; the latter – to continuing professional education programs intended for the executive staff of companies, enterprises and establishments.

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UDC 378

# Tools and Indicators for a Dynamic, Innovative and Optimized Education Program

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**Table and indicators which allow a rapid analysis and comparison of education programs are presented. Among them, the matrix of competences is very useful to check that targeted skills are really fulfilled by the education program. In addition to the analysis of the curriculum, benefits, limits and opportunities provided by innovative learning process like Project Oriented Learning, Reverse Engineering Learning and Online courses are discussed.**

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***Key words:*** *matrix of competences, Reverse engineering, Online courses, Innovative learning process.*

## Introduction

Any Education program has to be designed according to objectives concerning:

- the targeted profile of graduated students, their short term and long term activity and agility
- the requirements and expectations from industry and society
- the strategy of the institute
- the strategy of the state

Society needs, company needs, students' attitude and standpoint are rapidly moving. The technology enables now a very rapid and worldwide access to data, provides new tools for education but also results in a significant change in the time students are able to concentrate hard enough and in the way they are collecting and recording information. Therefore any education program has to be dynamical but also innovative. Considering that any education institute has to respect requirements from accreditation system, considering that its budget is finite and knowing that any academic staff is somehow reluctant to changes or less rapid or motivated to integrate new tools or learning processes, the design of any education program and organization is indeed an optimized process managing many parameters or constraints. In this paper, first the matrix of competences is presented and indicators allowing easy analysis and comparison of education program are proposed. Then Strengths, Weaknesses Opportunities and Threats (SWOT) of learning processes like Project Based Learning (PBL) or Reverse Engineering Learning (REL) are discussed. In a third part, opportunities provided by On Line courses and discussed and fourth part is dedicated to the conclusion.

## I- Matrix of competences and synthetic analysis of education programs

Whatever the level of education, the curriculum has to provide the knowledge and professional/technical competences required for the domain of activity (chemistry, communication, transport, energy, banking ...) and targeted professional tracks (Expert, Manager, Designer, Entrepreneur...) [2 , p5]. The matrix of competences presented in figure 1 allows an easy analysis how competences are provided in each module of the curriculum and is an easy identification process of missing competences. Some clues for changes in the curriculum can thus be provided. This matrix is also a precious tool for external communication from the institute. Furthermore the matrix is useful to graduated students, especially during recruitment interviews : students get aware of their competences which are listed in the matrix and get also able to name and justify their skills. This competence matrix which is curriculum's content oriented must be completed by other tables mentioning the form or education (classical learning processes, innovative learning processes like Project Based Learning (PBL see II) or Online courses (see III), interships...) related to each skill. Many indicators can also be listed which allow comparison between education programs structure worldwide and exchange of best practices. Indicators like share of Academic staff from industry, share of education in English, share of PBL, share of Online courses, share of humanities, share of interships, number of entrepreneurs among alumni, ... are for example useful indicators.

## II- SWOT analysis of Project Based Learning (PBL) or Reverse Engineering learning (REL)

Project based learning is very fruitful to students for many reasons. They have to take initiatives, use in the most efficient way their knowledge and skills, cooperate and communicate with others. This is an introduction to the 'real world', the professional way of working in companies. Project based learning is relevant for promoting or encouraging acquisition of fundamental or specialized knowkedge and skills but is less suited to acquire them. "Classical" learning processes (Lecture/Exercise/Labwork) are efficient in that case and profitable in terms of time to spend in order to acquire theses fundamental or specialized knowledge and skills.

Reverge Engineering can be organized in a project oriented learning way. In that case, in addition to the usual PBL contribution to education of interpersonal skills, like management and enterprise ecosystem, Reverse Engineering allows a direct connection to education of intellectual property and related strategy, to ethics, and even to state policy regarding protection of national economy.

To sum up, a SWOT analysis of PBL and REL could be the following one (Table 1).

## III- On line courses: opportunities and stakes

Massive Open Online courses (MOOCs) are rapidly growing new opportunities for users (young students or even professionals aiming at updating their knowledge) to learn and even get credits from prestigious Universities. The list of available courses proposed by 'Coursera' [3] is for the moment the largest one thanks to the cooperation of many universities worldwide. Many top universities have also strongly invested in the development of Edx [4] and in many countries digital platform are created to develop MOOCs [5, 6]. For universities proposing MOOCs, one of the payback is the renown, the advertising, the image of a university adapted to the 'Z' generation or 'digital natives' [7]. MOOCs are also the opportunity for a new market related to education and dedicated platforms. MOOCs include an evaluation process and due works that have to be sent by users before deadlines. MOOCs are broadcasted at specific date and time and thus users have to connect to the platform at fixed schedules. A more flexible process also exists and is proposed by some university. In that case, free online courses are available, can be viewed anytime and associated handouts are available [8, 9]. These

**Table 1.**

| Strengths | Weaknesses |
|---|---|
| ■ Motivation of students and emulation<br>■ Providing confidence to students<br>■ Mobilization of knowledge and competences from different modules | ■ Less suited or less efficient to acquire fundamental/spezialized skills than classical highly tutored education process (Lecture/Exercise/Labwork)<br>■ Time consuming due to project management and organization |
| **Opportunities** | **Threats** |
| ■ Can be related to other modules of humanities : Project Management, Communication, Intellectual property, Ethics, Team working...<br>■ Development of industrial partnership: project can be proposed by company | ■ Students may hide behind other<br>■ Scientific and technical Knowledge and skills may not be used or trained because of tasks splitting and sharing between students |

**Fig. 1. Example of competence matrix. Skills are sorted into large domain. If an education module addresses one skill, a value of one is inserted in the corresponding box. For each module, the total of addressed skills is calculated and for each skills the total number of modules addressing this skill is calculated. Skills can easily be adapted to any curriculum. Some skills common to any curriculum can be found in [1] and [2]**

| | Analysis | | | Method | | | Conception / Creation / Innovation | | | | Humanities | | | Special skills of a specific domain For example: nuclear engineering | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Modules | Functional analysis of the problem and segmentation in hardware or software related functions | Critical analysis of the situation a solution, a reasoning | Understanding the physical processes involved in the system | Definition of work planning taking into account avalaible resources (manpower, competences) and technication specifications of a project | Analysis and evaluation of costs and risks | Design or settling method for avoiding or identify possible failure / Design of tests for validation of a solution and validation of specifications | Gathering and development of ressources, knowledge and skills for innovate | Defining of detailed functional and technical specifications | Design of a hardware or software solutions well suited to present or new needs, requirements or standards / Modellisation and Simulation | Stakes, benefits and risks of entrepreneurship / Design of a strategy for concerning intellectual property | Autoevaluation, evaluation of its own role and the role of colleagues | Teamwork and communication | Agility and the ability to self-development and improvement in global environment / Work in a multidisciplinary and multicultural team | Ensuring safety of a nuclear installation | Modeling on of neutronics in a nuclear plant | Operating in a pressurized water reactor | Total |
| Mandatory modules | | | | | | | | | | | | | | | | | |
| Science module 1 | | 1 | | | | | | 1 | | | 1 | | | | | | 3 |
| Science module 2 | | 1 | 1 | | | 1 | | | 1 | 1 | | 1 | | | 1 | | 7 |
| Science module 3 | 1 | | | | | | 1 | | 1 | | | | | | | | 3 |
| Foreign language | | 1 | | | | | | | 1 | | 1 | 1 | 1 | | | | 5 |
| Labor law | | 1 | | | | 1 | | | 1 | 1 | | | | | | | 4 |
| Ethics | | | | | 1 | | | | | 1 | | | | | | | 2 |
| Project | 1 | 1 | | 1 | 1 | | 1 | | 1 | | 1 | 1 | 1 | 1 | 1 | | 11 |
| Internship | 1 | 1 | 1 | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 15 |
| Elective modules | | | | | | | | | | | | | | | | | |
| Module 1 | 1 | | 1 | | | | | 1 | | | | | | 1 | 1 | 1 | 6 |
| Module 2 | | | 1 | | 1 | 1 | | | 1 | | | | | 1 | 1 | 1 | 7 |
| Total | 4 | 6 | 5 | 1 | 4 | 4 | 3 | 3 | 8 | 4 | 4 | 4 | 3 | 5 | 5 | | |

kind of on line courses are really suited to present and future student attitude and to the technology that allows high rate access to data anywhere anytime. This means that professors can record their lecture, put it on the platform and then decide to replace part of their lectures in lecture halls by sessions of questions/answers, after students listened to the lectures in advance on their tablets when they were the most ready to. Examination can still be organized in the same way as before (which guarantees that students will listen and study the lecture). These lectures will not replace the labworks of the curriculum since many of them (especially ones requiring dedicated equipment or facilities) cannot be provided through MOOCs and online course. Labworks are very efficient time slots for direct communication and tutorials of students and are thus valuable learning processes. Such open on-line lectures, included in the curriculum but free of any embedded evaluation or certification process, are quite easy to implement and can thus be easily designed and shared between partner universities. They will also provide opportunities to students to learn in different languages or to benefit from lectures from experts. These lectures are also suitable to continuing education or distant learning as part of the curriculum.

## Conclusion

Education curriculum and education processes depend on many parameters, culture and tradition, relation with industrial world, needs from the society, technology..... The selection of the content of education modules is determined by the knowledge and targeted competences. The matrix of competences may help to select most suited modules or to adjust modules. Project oriented learning was tested many years ago and is now included in most curriculums. The global and rapid access to data requires adaptation and best use from the academic world (staff and institute) to this technology. The share of education using PBL and online courses has to be fixed according to objectives in terms of specific targeted skills, in terms of improvement of student's self-investment in education and considering that education institutes are in competition not only for research but also for recruiting students. Part of their attractiveness depends of their image and their agility to adapt to innovative learning processes.



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# Intelligent Data Analysis in Quality Management Problems of Education Process

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**The article describes the Intelligent Data Analysis (IDA) system model applied to the University education process, the possiblities of IDA in consideration of the characteristic education aspects and its application.**

***Key words:*** *educational process, quality management system, data analysis.*

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For effective operation of university quality management system it is necessary to establish an IT environment, which, in its turn, could control the process of capturing and data analysis. University IT environment is the representation of university process intelligence within the framework of IT. According to [1], quality management system within any university cannot be considered to be integral and effective without applying those tools which would monitor the education process itself through IT.

Thus, the research target is to apply Intelligent Data Analysis IDA methods in the quality management problem-solving of the education process.

One of the eight principles of the International Standard ISO 9000[2] is the following approach to decision-making based only on facts. The implementation of this principle involves the analysis and capturing of reliable and accurate data relevant to the assigned task.

Capturing and further data analysis involves a definite possession of knowledge and use of specific methods. One of these methods is the so-called Intelligent Data Analysis (IDA), providing more interesting data rather than in the case of obtained average data [3].

Intelligent Data Analysis (IDA) of the education process allows solving the following problems:

- defining the cluster of students being in the risk group of academic progress;
- on-the-spot analyzing enormous volume of data (for example, the results of current and final assessment) and detecting departure from normally running sequence;
- detecting problem situations in the education process and defining their causes;
- analyzing accumulated data to improve the education process.

Characteristic aspects of data analysis within the education system involves the fact that solving such problems includes modeling, which in its turn, reveals the data pattern itself. In this case, the descriptive model has become one of the most in-demand models which facilitate a deeper understanding of the analyzed data. The key point of these model results is that they are simple and transparent for human perception. It is probable that the defined patterns are characteristic for specific experimental data, regardless of the fact that this data may not be encountered anywhere, but may be practical and so must be studied. Clustering and search of association rules are classified as such kind of tasks [4].

At the present moment the forecasting problem in the education system is of less significance than that of a problem description. This is closely related to two facts: the education system itself is changing quite rapidly and there exist a great number of indirect factors.

Effective implementation of Intelligent Data Analysis (IDA) exists through free software products as back code implementation from common algorithm or stand-alone (SAS Enterprise Miner, Poly Analyst, Deductor, RapidMiner), as well as different tools integrated into data base management system – DBMS (Oracle Data Mining, SQL Server Analysis Services).

Applying off-the-shelf algorithms as back code is rather time-consuming, and in case of applying IT system stand alone applications, data selection and cleaning will be executed in on-line mode and data is exported in the format which is supportable for the external toolkit. Further data manipulating, visualizing and applying analysis method occur independently from the IT system. In this case, it is considered that the most appropriate method is those tools integrated into DBMS. The advantages of this approach are the following:

- possible integration of multivendor data;
- application of built-in data origination facility to intelligent analysis;
- selection and application of different IDA algorithms;
- store and reusability of models;
- possible comparative analysis of different effective models.

To implement the quality management tasks of the education process, an analytic education portal subsystem was designed at Eastern-Kazakhstan State Technic University (EKSTU), n.a. D. Serikbaev, which in its turn, provided the possible analysis through the tool Data Mining [6]. This subsystem included the following process and functions:

- compilation of education process statistics;
- designing multidimensional IDA database;
- data consolidation from different independently developed codes to analytic subsystem database and its management and application to perform online information-analytic and intelligent analysis;
- IDA implementation;
- preparation and presentation of IDA results for the analyst (or management representative);
- administrator access rights to information-analytic subsystem resources.

During the period of 2009-2013 168 066 write-records were generated for processing experimental data within the framework of the model "Online information-analytic and intelligent analysis", including 100 839 write-records in "Training set"; 40 336 write-records in "Testing set" and 26 891write-records in "Planning data".

The following IDA tools were applied in the analysis:

- decision-tree algorithm;
- neural net algorithm;
- simple Bayes algorithm;
- clustering algorithm;
- logistic regression algorithm [5].

IDA model defines what combinations of input variables trigger either high or low academic progress, which in its turn, isolates the student risk groups.

The results of education process data modeling is depicted below, i.e. Fig.1 shows the classification results of decision-tree algorithm.

Fig. 2 shows a window with dependency network for decision-tree solutions to define those factors influencing the results of semester-exams.

Based on the algorithm results of designed dependency network for decision-tree the following factors were defined which influence the results of semester-exams: discipline, administering department, absence rate, based-learning and course. The most significant factor was "Absence rate."

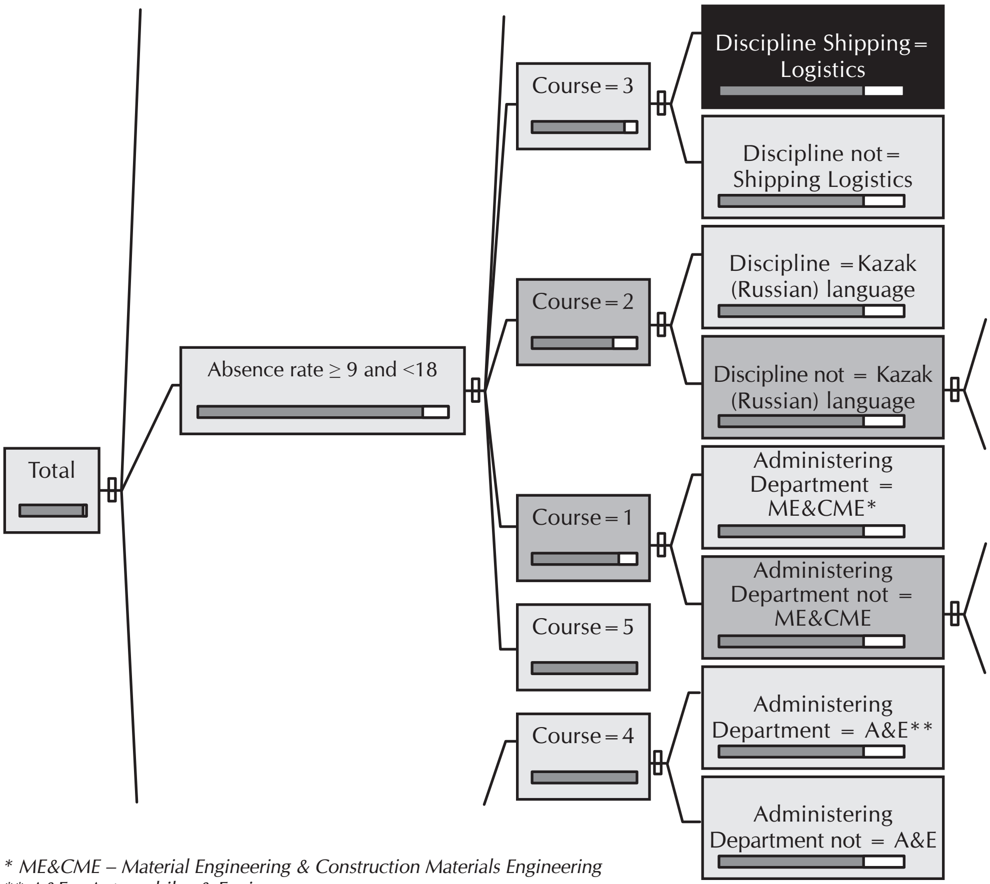
Fig. 3 shows the IDA results based on the neural net algorithms

The results of the classification based on Bayes algorithm is depicted in Fig. 4. According to the report of attribute comparison based on Bayes algorithm, the major factor influencing "failed semester exam" is the "absence rate."

According to Fig. 5, dependency network for Bayes algorithm showed that there are more factors influencing "semester-exam: passed" in comparison to the dependency network based on the decision-tree solutions. Based on the algorithm results of designed dependency network for Bayes model the following factors were defined, which influences the results of semester-exams: discipline, number of credits, absence rate, based-learning, course and learning language. Thus, the IDA of the education process was conducted based on the implementation of the following



**Fig.1. Window with Fragment of Decision – Tree, Where Every Block Shows Probability of Variation (Passed \ Failed)**




** ME&CME – Material Engineering & Construction Materials Engineering*
*** A&E – Automobiles & Engines*

**Fig. 2. Algorithm Results of Designed Dependency Network for Decision-Tree Solutions**

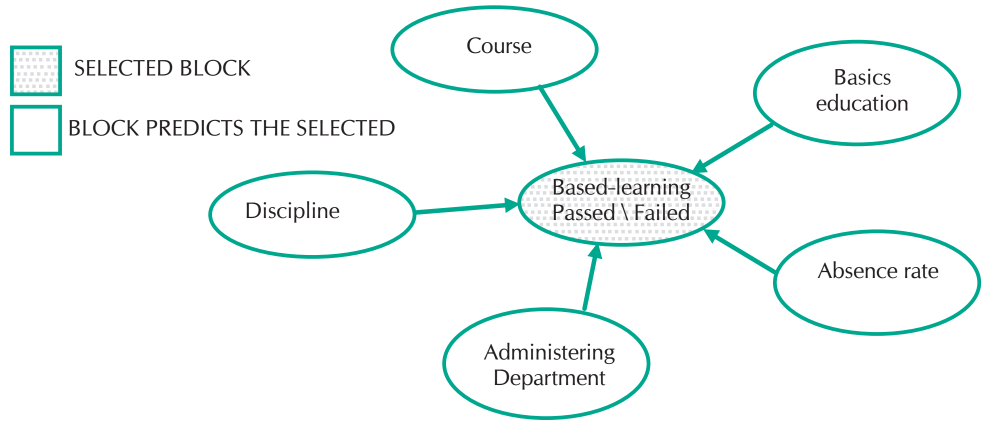



**Fig. 3. Results of Classification through Neural Net Algorithm**

| Attribute | Notion | Failed |
|---|---|---|
| Discipline | History of Economic Science | |
| Speciality | 50304 | |
| Discipline | Money, Credits, Banks | |
| Discipline | Statistics | |
| Discipline | Shipping Logistics | |
| Discipline | Economic Data Processing | |
| Speciality | 50724 | |
| Speciality | 5B090100 | |
| Speciality | 5B050700 | |
| Discipline | Fundamentals of Electric Engineering | |
| Administering Department | Economic Law (EL) | |
| Speciality | 5B050900 | |
| Speciality | 5B050600 | |
| Speciality | 5B050800 | |
| Speciality | 50806 | |
| Faculty | Finance & International Trade (FIT) | |
| Speciality | 50507 | |
| Speciality | 50508 | |
| Discipline | Financial Markets and Brokers | |
| Discipline | Advanced Course in Mathematics | |

algorithms: decision-tree, neural net and simple Bayes model.

The above-mentioned results of different analysis types could be practical not only for administrators in solving management and organization issues, but also for students, who would be able to reasonably predetermine his\her abilities and develop his\her own learning strategies. Introducing on-line IDA facilitates the possible closed-loop management cycle of the education process itself.

Information-analytic subsystem architecture for any university is depicted in Fig. 6.

In conclusion, the information-analytic system of university education process quality management should not only provide information about the current and future processes, but also define those problem areas within the university education process itself, develop corrective actions to intensify the above-mentioned result-oriented processes. Corrective actions involve the results of online and intelligent processing, which in its turn, identifies the quality of the education process and propose hypotheses relevant to those methods improving this process.



**Fig. 4. Results of Classification Based on Bayes Algorithm**

| Attributes | Notion | Passed | Failed |
|---|---|---|---|
| Absence rate | 0 | | |
| Course | 4 | | |
| Course | 1 | | |
| Course | 2 | | |
| Speciality | 5B042000 | | |
| Based-learning | Contract | | |
| Based-learning | Grant | | |
| Speciality | 5B090100 | | |
| Absence rate | 20 | | |
| Absence rate | 23 | | |
| Absence rate | 27 | | |
| Absence rate | 18 | | |
| Course | 5 | | |
| Absence rate | 25 | | |
| Absence rate | 14 | | |
| Absence rate | 12 | | |
| Speciality | 50729 | | |
| Absence rate | 17 | | |
| Absence rate | 10 | | |
| Absence rate | 15 | | |

**Fig. 5. Results of Plotting Dependence Grid for Bayes Algorithm**

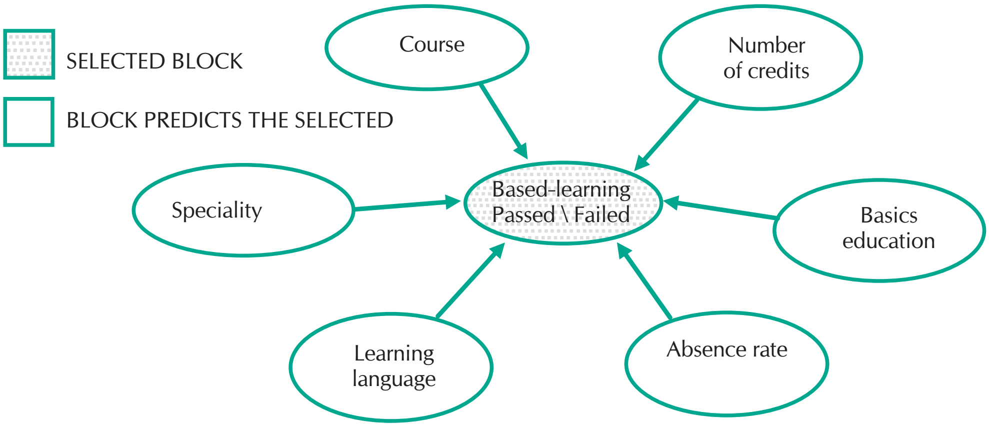
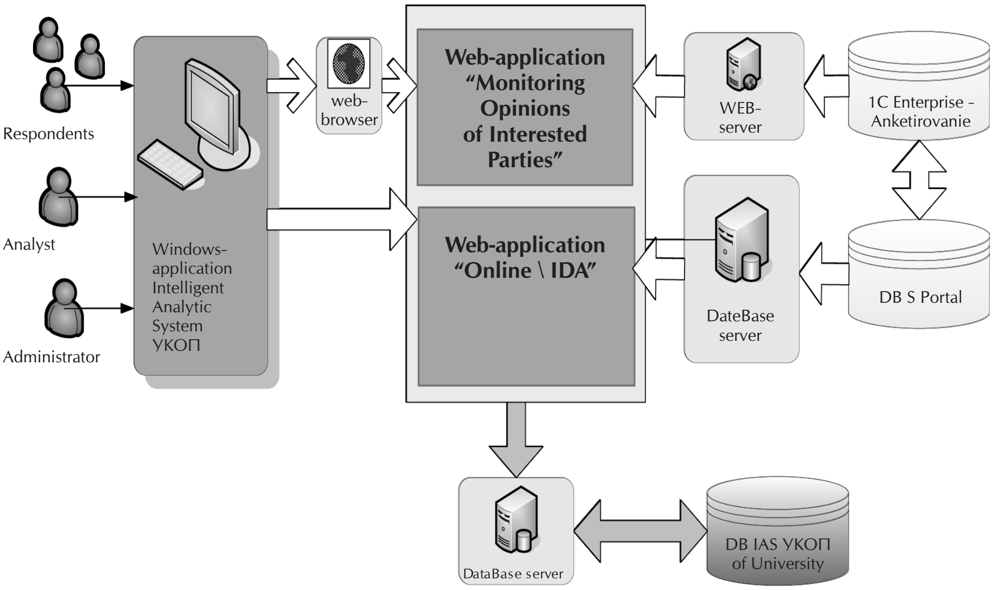



**Fig. 6. Analytic Subsystem Architecture**

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# Organising Educational and Training Process in Cooperation with Employers

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**Best practices of university interaction with employers within the educational process are presented. The paper describes an example of cooperation between the Institute of Civil Engineering and Architecture (MGSU) and employers - the construction enterprises in Moscow and Moscow region. Some forms of joint projects that improve the quality of students' training are given.**

***Key words:*** *higher education in construction, employers, master, bachelor, engineer-constructor, the main educational program.*

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In 2013 Moscow State University of Civil Engineering celebrated its 92 years anniversary. Moscow State University of Civil Engineering was established in 1927. It is is one of the best universities in the country and holds leading positions among universities in the field of civil engineering.

Today MGSU includes seven institutes:

- Institute of Construction and Architecture
- Institute of Environmental Engineering and Mechanization
- Institute of Hydraulic Engineering and Power Plant Construction
- Institute of Economics, Management and Information Systems in Civil Engineering and Real Estate
- Institute of Urban Engineering and Real Estate Management
- Institute of Basic Sciences
- Institute of Distance Education

One of the leading institutes of the University - Institute of Construction and Architecture (ICA). It was established in 2003 on the basis of three faculties: Faculty of Industrial and Civil Engineering, Faculty of Construction and Technology, Faculty of Engineering and Architecture. Before 2011 the Institute ensured education in three specialties: 270102.65 "Industrial and civil engineering", 270106.65 "Construction materials, products and structures", 270114.65 "Design of buildings".

Since 2011 MGSU has made transition to a two-tier system of education and ICA began admitting students for Bachelor and Master programs. The teaching staff of the ICA developed and introduced main educational programs (MEP) in all fields of training. Together with faculty members of various departments representatives of leading construction companies contributed to the development of MEP. They were not only involved in the curricula development process, but also initiated introducing of new profiles and fields of Bachelor level training.

For example, the profile "Cost Engineering" was initiated by the Federal Center of pricing in construction, ANO DPO "Institute of Cost Engineering" and by large construction companies, such as SU-155, Mostpromstroy, Glavstroy, Moststroymehanizatsiya, Monarch and others. Such interest of the enterprises could be explained by their need for professionals who have knowledge in the field of investment and construction process and procedure of construction costs definition. Graduates from the program could be employed in public construction companies, joint stock companies, joint ventures engaged in the construction and operation of facilities, design and project organization. Within the collaboration the main competences required by industry from students upon graduation from Bachelor degree program "Construction" and "Cost Engineering" were identified. They must have a wide range of engineering and economic knowledge.

Below there is a list of companies involved in the development of main education program in the field of Construction:

- Profile "Industrial and civil engineering" and the specialty "Construction of unique buildings and structures" – LLC "Vibroseysmo-zaschita", CJSC "Mospromstroy", the First national organization of builders, the National Organization of prospecting engineers, Creative Production Association "Reserv", Group of Companies "SU-155", OJSC "TSNIIEP zhilische";
- Profile "Design of Buildings" – the group of companies "SU-155", the Union of designers of Russia, OJSC "TSNIIEP zhilische";
- Profile "Construction materials, products and structures" – Moscow State Unitary Enterprise Scientific Research Institute of the Moscow construction NII Mosstroy, SPC "Spetspolimer", LLC "Saint-Gobain Construction Products Rus";
- Profile "Cost Engineering" – the initiators of profile development were the Federal Center of pricing in construction, CJSC "Mostfundamentstroy", CJSC "Mospromstroy", Samara Institute of Economics and Real Estate;
- Profile "Urban Construction" – the First national organization of builders, the National Organization of prospecting engineers, Creative Production Association "Reserv".

Today the Institute continues engineer's training together with bachelor and master training in the fields and specialties shown in Table 1:

To provide full-time, part-time and distance training the Institute of Construction and Architecture has 14 departments, 11 training centers, 21 laboratories and 2 Scientific-educational divisions (Table 2).

To use the full capabilities of laboratory and research facilities of institutions when choosing the topics for graduate and post-graduate theses that could be required by industry MGSU appealed to the Board of Trustees, which includes representatives of construction companies in Moscow and Moscow region with a proposal to formulate relevant topics for master and postgraduate theses. The following companies has responded to the proposal: "Monarch", "SU-155", "Inteko", "Mosfundamentstroy-6", "DSK-1", "DSK-2", "Knauf", "Doc Rus" and others. As a result, more than 100 scientific and industrial topics were given that could be interesting for representatives of the leading construction companies, and directly related to their business or they seem profitable in the future and can be implemented in MGSU.

Close cooperation with the industry gives large opportunities for the development of targeted training of postgraduate students. Graduate student could take scientific internship training at enterprise and be engaged in research, using available facilities. At the same time the company manage his/her professional skills: his intellectual potential, strengths and weaknesses. Professional staff will always be in demand in developing production, so such students undoubtedly even during training will receive an offer to take up the position corresponding his level of skills with the possibility of career advancement.

The Institute already has such experience of students' targeted training. This form of interaction with employers has been developing since 1987.

For long years there is a contract aimed at targeted training of engineers of the specialty 270102 "Industrial and civil engineering" with OJSC "Central Research and Design Institute of residential and public buildings" (TSNIIEP zhilischa). Based on the projects of this institute, founded in 1949, large housing estates, typical and individual houses of varying heights, public welfare buildings and cultural facilities were built in our country and abroad. Currently one of the main activities of the TSNIIEP zhilische is design of high-rise residential buildings, project planning and development of large urban

**Table 1. Areas of training specialists in ICA MGSU**

| № | Fields of study, profiles, programs | Qualification | Number of terms |
|---|---|---|---|
| | Bachelor and Specialist degrees | | |
| 1 | Construction<br>■ profile "Industrial and Civil Engineering"<br>■ profile "Design of Buildings"<br>■ profile "Construction materials, products and structures"<br>■ profile "Cost Engineering"<br>■ profile "Urban Construction" | Bachelor | 8 |
| 2 | Architecture | Bachelor | 10 |
| 3 | Urban Planning | Bachelor | 10 |
| 4 | Standartization and certification | Bachelor | 8 |
| 5 | Technosphere safety | Bachelor | 8 |
| 6 | Specialty "Construction of unique buildings and structures"<br>specialization #1 "Construction of high-rise and long-span buildings and structures" | Specialist | 12 |
| | Master programs | | |
| 1 | Construction<br>■ Theory and design of buildings<br>■ Urban planning and architectural design principles of accessible environment<br>■ Technology of finishing and isolation materials<br>■ Nanomodified building composites for general construction and special purpose<br>■ Architectural and Construction Materials<br>■ Polymeric Construction Materials<br>■ Physics of the environment and functional bases of designing energy-efficient and convinient buildings<br>■ Upgrade and restoration of buildings and structures<br>■ Theory and practice of organizational and technological solutions | Master | 4 |
| 2 | Architecture<br>■ Architecture and design of buildings and structures | Master | 4 |

**Table 2. The ICA laboratories and scientific-educational centers**

| № | MGSU ICA laboratories and scientific-educational centers |
|---|---|
| 1. | Laboratory of the department "Construction Materials" |
| 2. | Laboratory of the department "Polymeric construction materials and applied chemistry" |
| 3. | Laboratory of the department "Technology of finishing and isolation materials" |
| 4. | Laboratory of construction physics of the department "Architecture of civil and industrial buildings" |
| 5. | Laboratory of the department "Reinforced concrete and masonry structure" |
| 6. | Laboratory of the department "Metal structures" |
| 7. | Laboratory of the department "Timber and plastic structures" |
| 8. | Laboratory of the department "Technology of binders and concretes" |
| 9. | Laboratory of the department "Polymeric construction materials and applied chemistry" |
| 10. | Laboratory of the department "Testing of structures" |
| 11. | Labour protection Laborartory of the department "Integrated Safety in Construction" |
| 12. | MGSU – KNAUF Laboratory |
| 13. | DOKA – MGSU Laboratory |
| 14. | Labour protection Laborartory of the department "Integrated Safety in Construction" |
| 15. | Sector for testing of stuctures |
| 16. | Research Laboratory "Inspection and reconstruction of buildings and structures" |
| 17. | Sector of translucent structures |
| 18. | Laboratory of fire and explosion safety of the department "Integrated Safety in Construction" |
| 19. | Laboratory of production safety |
| 20. | Testing Laboratory "Technical regulations and Quality" |
| 21. | Research Laboratory "Urban planning and quality assessment of the living environment in settlements" |
| 22. | Research Laboratory for the study of the actual work of construction of buildings and structures |

communities (housing estates)in Moscow, Moscow region and other regions of Russia.

The organisation of "TSNIIEP zhilischa" was based on an order which involved the formation of a group of ICA students of senior courses (5-8 semesters) within the framework of the curriculum. To work in groups at design departments, they are assisted in solving practical problems in the implementation of the course and diploma projects. They have all the conditions for practical training and are paid an additional scolarship. Under this program, the Faculty of Industrial and Civil Engineering and the Institute of Construction and Architecture have trained more than 250 engineers.

Since 2002, our institute has started to form more targeted training groups in collaboration with other building organizations. Such groups are formed from senior students (usually a fifth-year students) who have shown their interest in a particular construction company and wish to work there upon graduation. Recruitment is carried out after the company's presentation and students' meeting with the management.

Taking into account specific goals and activities of particular construction company a special targeted training program(100-150 hours length) has to be developed with participation of experts from the company. The main feature of the program – its practical orientation (approximately 50% ). Practical classes are held using the facilities of the construction company. Classes are provided by the ICA faculty involving other practitioners. The training costs are covered by the organization that asks for targeted training. Under this scheme, the groups of students for Holding Company "SU-155", "KIN" company and "Moskapstroy", design organizations "PI-2", "Reserv"and others were prepared.

When there is no state program of graduates' distribution and employment, the company itself is guaranteed to receive young professionals. Moreover within the training process (one academic year), students could adapt to the construction company where they will be working.

Summing up the experience of the ICA MGSU interaction with enterprises the following forms of cooperation between university- employers should bemarked out:

1. Involving construction companies in developing profiles of bachelor and master degree training;
2. Providing targeted training, including retraining, continuing professional development;
3. Formation of research topics for Master and PhD students suggested by enterprises;
4. Organization of internship training;
5. Employment of graduates;
6. Economic agreements, joint research;
7. Board of Trustees.

These forms of cooperation, of course, need to be developed by studying best practices of leading Russian and foreign higher education institutes in order to find new areas of activity, which improve the quality of educational process at universities in the field of civil engineering.

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# Ability toWork in Professional Community as Universal Competence of a Modern Engineer

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**The author analyzes the meaning of "competence for collective work" as engineer's ability to work in professional community. She reveals the content and structure of the competence, discovers its influence on whole pedagogical process in higher education.**

***Key words:*** *competence, universal competence, qualification, professional skills, professional experience, professional community, professional consciousness, professional thinking, professional mentality, standard of professional behaviour.*

**I.G. Kartushina**

Professional skills and experience have always been key conditions for successful professional activity. These are the characteristics taken into account by employers if there are some applicants for one vacancy. Apart from it, the communicative nature of any work requires that all employees should be able to work in team. The importance of communicative skills is reflected in the description of universal (key) competences developed by the education structures of the European Union: "to study", "to search", "to think", "to collaborate", "to set about work", " to adjust" [2. p. 24].

Keeping with recommendations of the European Council the competence "the ability to work in team" includes the following skills:

- to ask for other opinions and to consult a specialist;
- to take part in a discussion expressing your own opinion;
- to work in a group, to adjust conflicts, to negotiate, to enter a team, to contribute to joint activities and to prove solidarity.

The above mentioned skills reflect the nature of interaction between parties of professional activity.

Russian system of professional education, which acts according to the federal state educational standards, traditionally refers development of this competence to Humanities and Social Sciences study area (HSS) [3]. The competence component of the basic part of this study area for engineers consists of the following competences, which, as we think, could be structured into universal professional competence of "working with others":

- ability to manage small groups (universal instrumental competence);
- ability for social interaction with society, community, team, partners, ability for collaboration and conflict adjustment (competences of activities, communication, public and private lives);
- ability for team work and cooperation, the skills to manage executors' activities and to come to decisions in case of different opinions (competences of teamwork);
- ability to work on interdisciplinary projects.

It is obvious that the description of the competence that is in opposition to the competence of "individual work" needs clarity and precision, which will make professional education more objective. In our opinion, this core element could be such a phenomenon as "professional community". Professional community is a variant of social associations organized for effective achievement of collective professional goals – to receive real labour product, to implement collective professional mentalities and values [1, p. 99].

Accuracy of formation of ability to work in professional communities as a universal professional competence is ensured by taking into account the hierarchy of professional communities (Fig.1).

Team work competence should be regarded as a category of work in professional communities. It determines a set of pedagogic objectives to form soft competencies that ensure effective joint activity based on, professional awareness, professional thinking, professional mentality and standard of professional behavior. Thus, in this case, the succession of the pedagogical process should be the following (Fig. 2).

It could be achieved by means of developing dual training system or net interaction of educational institutions.

The experience of Training Center of Auto-construction in Kaluga College of Informational Technologies and Control Systems (state autonomous vocational secondary institution) is very interesting. They, together with the Volkswagen Group Rus factory (Kaluga), implement a dual training system for technical staff. They adjusted German curricula and Russian educational standards for the following specialties: "Mechatronics", "Electrical and automatic system operation", "Auto service" and "Automechatronics" by paying more attention to practical training (internship) and to closer cooperation with the enterprises where the internships take place. The training Center gives theoretical knowledge and basic practical skills while the Volkswagen Group Rus ensures special training to develop particular practical competencies in professional environment such as: to acquire necessary special knowledge

**Fig. 1.**

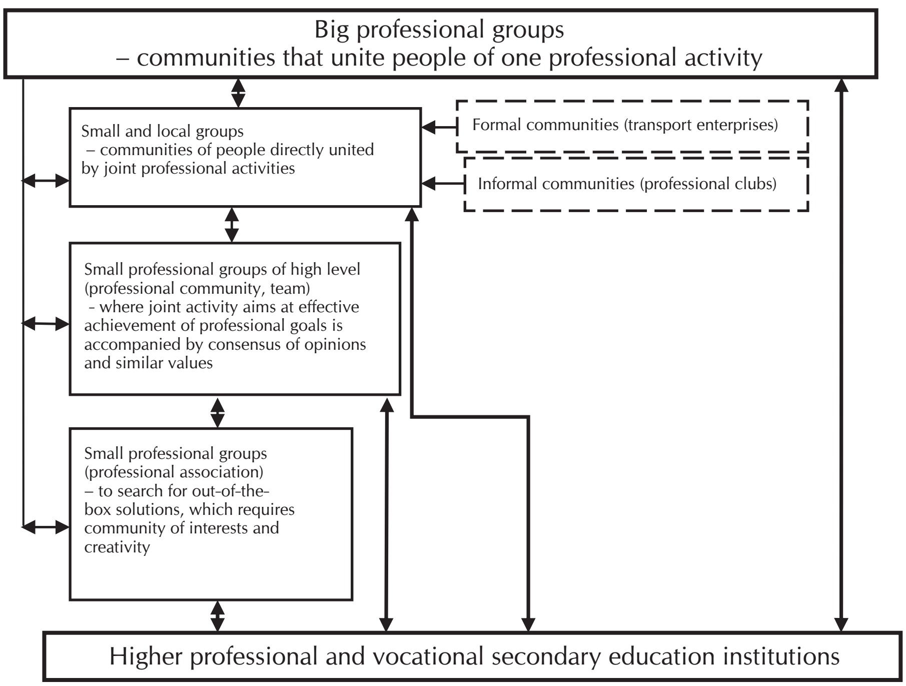
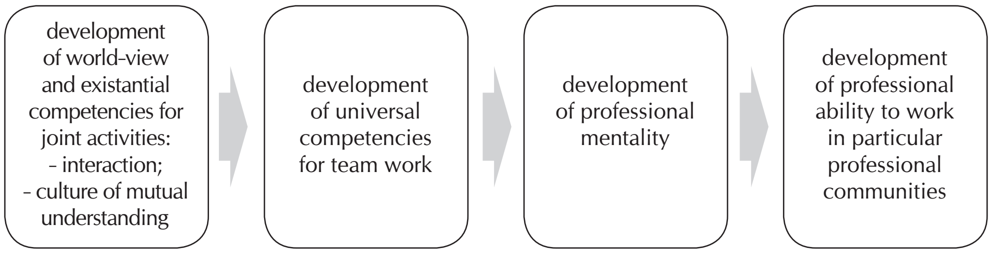


**Fig. 2.**




and skills, safety arrangement and precautions, use of quality management system, use of informational technologies, team work behavior, cooperative abilities, high working efficiency and focus on success, willingness for continuing education, etc. The dual system graduates receive diplomas of vocational secondary education and international certificate proving their practical competencies. Having team work competencies and practical skills these graduates are more ready for professional activity than the graduates who took traditional courses of secondary vocational education.

But it should be taken into account that the educational standards of vocational secondary education are mostly focused on acquiring particular practical skills for particular working specialty. Thus these standards cannot ensure training of highly qualified specialist with engineer's knowledge. The problem of higher education institutions is that their graduates filled with academic knowledge cannot or were not trained to work in real industrial environment. At the same time modern employers need highly qualified engineering staff with basic skills of workers who can operate hi-tech equipment, interpret drawings, use manuals written in Russian or foreign languages, apply information systems, work in team etc.

Thus, the conclusion is that competence as the ability to perform effectively professional activities as well as team working skills are developed in the process of personal participation in the work of a professional team but not in the process of work observation.

In 2014, Federal state autonomous educational institution of higher professional education "Immanuel Kant Baltic Federal University" plans to enroll students at bachelor and specialist degree programs such as "Technology of transport processes", "Service" and "Auto service" that are developed for students to acquire not only theoretical and practical knowledge and skills of the chosen specialty but also engineering qualification. In other words, they will be high qualified specialists of blue-collar occupations.

To develop curricula for Bachelors of applied science programs it is more reasonable to use modular-competence approach. This approach allows managing the training process adjusted for employers' needs while the students have possibilities to develop practical skills in the workplace, for example, by implementing interdisciplinary projects and solving the problems modeling real working environment.

The modular-competence approach fits into the framework of lifelong education concept, as its aim is to train highly qualified specialists who are able to work in a constantly changing working environment and keep on self-developing in professional area [4].

Thus, the training programs based on this approach will allow future graduates to adjust quickly to real working environment. Being flexible the programs can be easily updated and reorganized by changing some modules of a basic curriculum in response to changes of employer's requirements to the graduates, which greatly contributes to the graduate's competitiveness.

Another advantage of these programs is a possibility to create an individual learning path by combining modules and developing net educational programs between educational institutions and enterprises.

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UDC 378.147

# Technical mechanics within Technology Teachers Training System

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**Based on the theoretical analysis and practical experience grounded circuit integration course Technical Mechanics, which eliminated duplication of technical disciplines in the system of training the teachers of technology.**

***Key words:*** *technical mechanics, technical knowledge, technology teachers training system*

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Yu. Pavlovsky

## The Introduction

The knowledge of mechanics within technology teachers training system is important not only for learning the basics of statics, dynamics, various deformations and rating machine elements, but also for creating a basis for further knowledge acquisition in the sphere of vocational training.

The first knowledge of mechanics was acquired by the future technology teachers at the lessons of Technical Mechanics, introduced as a package of several disciplines though abridged to some extent in comparison with those studied in technical colledges. A systematic training of technology teachers started in late 1960ies, though attempts to combine this profession with other specialities had been made earlier [1]. Particularly, there were such qualifications as a teacher of physics and technical mechanics, a teacher of physics and fundamentals of production. Besides, some engineering specialities were combined with education in order to train teachers for the schools of vocational training. As an independent speciality, its name varied together with the changes of qualifications, until the final decision was made to make the name of the teacher's qualification sound exactly as the subject taught at school.

Over ten years research has been conducted aimed at optimization of integrated knowledge of the technical mechanics for the future teachers of manual labor and technology. Despite the variations of the name the essence of the speciality, the structure of the technical mechanics has remained unchanged though it was not a separate learning subject before. More than ten years ago in the desire to create integrated courses, such separate disciplines as Theoretical Mechanics, Strength of Materials and Theory of Mechanisms and Machines were artificially combined into one [2]. This was the approximate scheme under which the technical mechanics was taught in technical colleges. Moreover, research is being made aimed at improving the methods of teaching several parts of mechanics within such an integrated course. Therefore it was necessary to approximate the structure and the content of this course to that of the Technology subject taught in comprehensive schools.

## The main material

Previously the syllabus of the learning subjects related to the technical mechanics varied according to the scope, having been modified in 1970, 1981, 1987, 1998 and 2001; whereby in the first two the course of the Technical Mechanics was refered to sciences – just like General Physics – rather than to professional traing. The first attempt to devise a really integrated course of technical mechanics was made by V. Kurok [3], whose course includes the following components: Statics, Kinematics, Dynamics, Basics of Machine Elements Rating. Here the emphasis is placed on the theoretical mechanics, even the names of the chapters have been retained, Statics, Kinematics and Dynamics being the parts of the Theoretical Mechanics course. But the practical experience made it necessary to be improved by introducing certain corrections and additions without changing the integration principle. This scheme avoided the repetition of studying the same technical disciplines while training engineers and the content of the integral course was more adequate to the scope of technical tasks faced by the teacher. Thus, the scientific foundation of the new approach towards integration of the technical mechanics course raises no doubts. The role of integral knowledge of technology for the teachers of manual labor has been studied by many scholars who came to the conclusion that the knowledge integration leads to fundamentalism of education which, applied to the teacher of technology, is realized by comprehensive and technical training.

When changing from the classical model to the 4-tier system of manual labour teachers training the technical mechanics syllabus was significantly reduced in hours which adversely affected the professional qualifiacation of the teacher. When the 2-tier system of teachers training was introduced together with the involvement of the Ukrainian higher education in the Bologna process the technical mechanics is taught to 2nd and 3rd-year students as is required by the bachelor's degree qualifications. The previous syllabus the reduction of hours dedicated to the technical mechanics let to a reasonable abridgement of the course content, and namely, not by excluding certain topics but by compressng the information according to the principle of expediency defined by the effective syllabus.

Analyzing the fundamental definitions of the technology and mechanics an integral harmonious system of modern technologis is observed. No technics and mechanics is possible without technologies, therefore the name of the integral course of technical mechanics reflects its content. The technical mechanics as a discipline has existed traditionally in the system of professional training of technicians and from 1991 to 1998 was included in the system of training manual labor teachers both in colleges of education and universities.

The majority of the production processes nowadays are performed by machines and mechanical devices. Their efficient application is possible only with the understanding of the processes within them. Herefore, it may be concluded that the understanding of the structure and the function of the machine is a social requirement in the modern society. The teacher of technology must bring this knowledge to the students which in its turn requires a sufficient level of the teacher's competence. A plenty of scientific courses study the functioning of machines and mechanism and it is impossible to embrace the whole spectre of the knowledge of machines.

At the first stages of the integration of the Technical Mechanics course the materials of the previous syllabus in theoretical engineering were used in accordance with the following model (Fig. 1).

This scheme removed the repetition of the same technical disciplines in the system of professional training of engineers and the content of the integral course reflected more the total technical knowledge required by the future teacher of technology. Due to the integral knowledge of technology the education is fundamentalized, and for teachers of technology this is performed by technical training.

However, even now some universities training the teachers of technology teach the technical mechanics accord-

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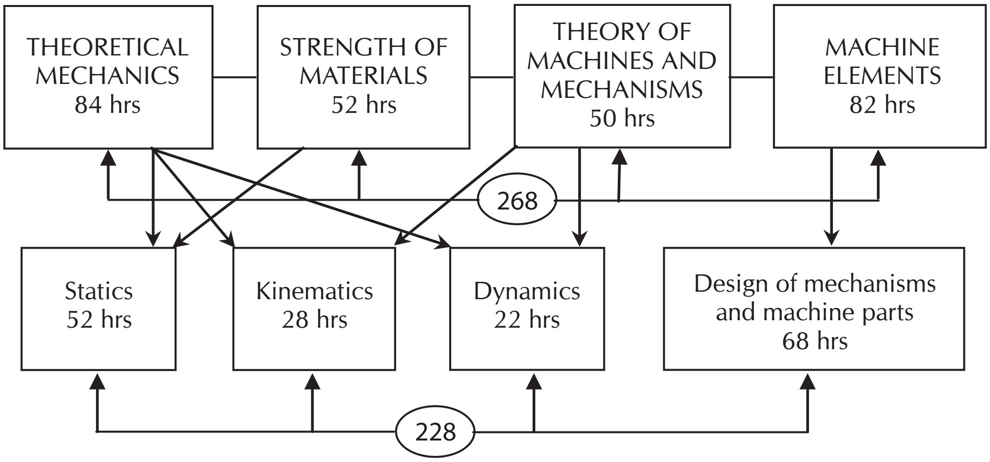
**Fig. 1. Scheme of the integration process of the Technical Mechanics course**




ing to the outdated scheme. Research is being conducted aimed at improving the methods of teaching some parts of mechanics according to such structure. Therefore the scientific substantiation of the new approach to the integration of the technical mechanics course is beyond doubt.

The intermediary stage of improving the syllabus of technical mechanics provided for structural modifications by introducing such courses as the statics of perfectly rigid bodies, the statics of complex systems, kinematics and dynamics, basics of machine elements design.

If we analyze the dynamic change of the hours dedicated to the study of technical mechanics we observe the tendency to their significant reduction, which may demonstrate the fact that the role of this discipline decreases or, worse, it has not found its place in the system of the professional training of technology teachers. The reduction of hours in the syllabus of the technical mechanics has lead to superficial study of widely used mechanical gears and auxiliary elements and some parts are excluded from the syllabus to be studied by the students independently. Therefore, a sysem analysis has been carried out which singled out the topics advisable to be included in the syllabus and the reseach activities which are sure to extend the knowledge and form and consolidate the skills.

An analysis of the manual labor syllabus in 5th to 9th grades of the secondary school demonstrates the fact that the topics of this discipline are extensively taught at the school lessons. The following topics should be pointed out:

- A general characteristics of machine elements used in technology. The notion of an element and mechanism. Types of mechanisms. Crank-and-rod mechanism.
- Kinematic diagrams, legend therein.
- Types of machine element joints. Threaded joint. Thread elements. Riveted joints. Types of riveted joints. Forces acting on rivets and their strength.
- Mechanical transmissions (belt drives, screw gears, rack gears).

The modern theory of education gave rise to numerous methods of teaching, however, from the viewpoint of information process only such methods can be called systemic, which provides for independent learning with the advisory aid of the teacher. Unfortunately, the syllabi rarely provide incentives for a creative learning by the students. At the same time, a yearly project is one of scarce creative works requiring an independent approach to application of a wide range of knowledge of technical disciplines. The designing process requires a systematization of the acquired knowledge, which activates the cognitive and creative activity of the student. Creative work is the evidence of almost completely trained professional. However, the classical methods of teaching have become rather outdated in the age of information technologies. Computers can and must be used while studying the integral course of the technical mechanics.

The integral components of the technical mechanics have been: the statics of perfectly rigid bodies, the statics of complex systems (strength of materials), kinematics and dynamics, basics of machine elements design.

They were studied in the above sequence, starting in the third through seventh terms. The 8th term was dedicated to applied mechanics. Having analyzed the syllabus based on the 10-year experience of teaching the subject we have come to the following conclusion. The discipline Statics of Perfectly Rigid Bodies shall be renamed Statics without changing its content and shall have the scope of 1.5 credits. Thereafter, Kinematics and Dynamics shall be taught (1.5 credits). The Statics of Complex Systems (Strength of Materials) shall be combined with the Basics of Machine Elements Design and renamed as Strength of Materials with Machine Elements Design retaing the total amount of hours (4.5 credits). The course shall be completed with selected problems of the applied mechanics with a yearly project. The syllabus for a 2-tier system of training for the bachelor's degree provides 432 hours for technical mechanics, including 168 hours lessons in class (70 lectures, 88 laboratory lessons). The study of technical mechanics begins in the 3rd term and ends in the 7th term, 2 hours weekly, while in the 7th term – 1 hour per week. The teaching of the integral parts shall be arranged as follows: in the 3rd term 2 hours for statics, 1 hour lecture, 1 hour laboratory lesson, final check – examination. In the 4th term 3.5 hours, including 2 hours kinematics and dynamics, 1 hour lecture, 1 hour laboratory lesson. In the 5th term just 1 hour including 1 hour lecture in. In the 6th term 3 hours to continue Strength of Materials with Machine Elements Design, including 1 lecture and 2 laboratory lessons, final check – examination. In the 7th term 2 hours for selected problems of the applied mechanics, including 1 lecture and 1 laboratory lesson, finalized with a yearly project. As it can be seen, the total amount of class hours is reduced from 180 to 168.

In accordance with the school syllabus and the interdisciplinary relations with other integral courses the content of each part of the syllabus includes the following. Statics, Kinematics and Dynamics shall include the issue of the statics of a material point and of a solid body as a whole. Here the main notions and tasks of statics shall be considered, including the connections and their reactions, composition of forces, system of convergent forces, momentum elative to the centre and axis, force couple, conditions of equilibrium, reduction of force system to the centre, coplanar force system. It is very important to study the statically definite and indefinite problems, spatial force system. Friction and its laws is one of the most important issues of mechanics. The ways to define the center of gravity coordinates, solving the problems in statics will be included as applied problems. Thereafter students shal be acquainted with the basic notions of kinematics, types of motion and ways of seting (linear and rotary motion of a point and solid, compound motion of a solid), plane-parallel motion of a body, kinematic couples and chains, the structure of planar and spatial mechanisms, kinematic study of lever mechanisms, kinematic study of cam mechanisms, dynamic study of planar mechanisms, types of friction in mechanisms being accounted for in designs, kinetostatic analysis of planar lever mechanisms, nonuniformity of motion of mechanisms and machines, fundamentals of motion control – this is a list of crucial issues to be studied after mechanics and basics of dynamics.

The Strength of Materials with Machine Elements Design are combined into a unity since all the theoretical problems of the strength of materials find their practical application in the machine elements design. Such integration avoids repetition of some issues of the strength of materials when designing machine elements. The theoretical information provided to the students includes the main hypotheses and assumptions, types of loads and major deformations, tensile and compressive deformation, strain energy, the notion of the strength hypothesis, theory of strength, statically indefinite problems, geometrical specifications of plane section, shearing, torsional and bending deformation, and with compound strain. The load dynamic action, requirements to machines, their elements, types of transmission, axes, shafts, bearings. Couples, mechanical connections, study of wave and planetary gears and drive units.

## Conclusion

Based on the theoretical analysis and practical experience grounded circuit integration course Technical Mechanics, which eliminated duplication of technical disciplines in the system of training the teachers of technology. Thus, the scientific substantiation of the integral course of the Technical Mechanics and the proposed structure of the discipline Technical Mechanics is aimed at activation of the student's cognitive activity by involving them into independent work.

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UDC 378.126

# Learning Motivation of Engineering University Students by Means of Pedagogical Support of Education

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***Yu.V. Podpovetnaya***

**Pedagogical support of student's training is a key factor influencing the process of learning student's motivation in an engineering university. This process is focused on formation of educated people meeting socially valuable requirements of the society. The given article reveals the conditions of educational environment in an engineering university focused on student's learning motivation, presents the characteristic of pedagogical support in engineering university student's training, analyzes the human resource of a subject in pedagogical support of student's training.**

**Yu.V. Podpovetnaya**

***Key words:*** *project-oriented technologies of the training, the practical-oriented technologies of training, engineering education, student's laboratory, competences, system of continuous education.*

In recent years the interest of scientists in studying different aspects of student's motivation for learning has increased. Theoretical-methodological analysis of scientific works on the given problem reveals the fact that by the present moment there is a sufficient volume of scientific-pedagogical research in this sphere [5; 6 et al.]. In addition, the analysis of sources has shown that at present there is no comprehensive theoretical ground of potential opportunities for pedagogical support of student's learning activity in an engineering university as a factor of their learning motivation. The conditions of university educational environment meeting the new demands of higher professional education system modernization in Russia have not been defined. Besides, the answer to the question about the role of human resource in the aspect of performing a subject's pedagogical support for student's educational activity has not been found.

To consider the given issues in this article let us fix on the characteristic of pedagogical support of student's education in an engineering university, revealing the conditions of a university's educational environment directed at student's learning motivation and analysis of human resource of a student's training management subject.

The distinguishing feature in student's education in a university is their interaction with teachers. University teaching staff organizes student's educational activity outside an engineering university [2]. It comprises some teachers' basic professional competences in educational institutions. Performing their competences teachers participate in the process of student's learning activity. They specify its content; choose the methods of interaction with students as well as manage the process of educational activity and its results. Such teacher's professional competences are referred to as pedagogical support of student's education [10].

In fact, pedagogical support of engineering student's education is a special form of outer management of university student's educational activity and learning student's motivation. Indeed, accompanying student's educational activity teachers act in accordance with the purpose to achieve the development of such their properties as correspond to socially valuable characteristics of an educated person. In a university educational process teachers use both personal resources and part of educational intuition's resources. Performing the support of students learning activity the teachers influence it. Hence, all features of management are typical for pedagogical support of students; learning activity. On this basis, university teaching staff is a subject of students education outer management.

Pedagogical support of engineering students education includes a subject's performance of outer management in students teaching, education, bringing-up, self-development competences in academic process using social and personal experience. In addition, teaching is based on a definite methodical idea developed by the teachers. It is obvious that the quality of methodical idea, its realization in the university academic process defines sufficiently the results of students training in an engineering university. Besides, the success of students involvement in academic-pedagogical interaction depends largely on the properly designed pedagogical support of students education that, in its turn, conditions students learning motivation and, as a result, students education, and their readiness for self-education [1].

Pedagogical support of students education is performed in the educational environment of a university. University's educational environment is characterized by definite conditions that influence students learning motivation. These conditions are of different aspects. They are equipment, means of academic activity (textbooks, visual aids, room and lab facility, sports equipment) etc. A particular aspect of educational environment conditions is related to university personnel's attitude to students (authority, teaching staff, and university-support staff).

Conditions of university educational environment are specially formed for students learning motivation and development of educated people, specialists, citizens. When forming the academic conditions of an educational institution directed at support of engineering students learning, it is appropriate to keep in mind the idea of educational environment that is characterized by the four basic coordinates:

- standard-regulating coordinate;
- perspective-focused coordinate;
- activity-stimulating coordinate;
- communicative-informative coordinate [5; 6].

Firstly, a subject of pedagogical support in students training builds standard-regulating conditions of university educational environment. It means that pedagogical support subject of students education follows the standards characterizing state-social intentions in education that include the requirements for a person's education and requirements for his/her safety within an educational institution.

Secondly, the government orientates educational institutions to the development perspective. For this purpose the documents are designed and adopted where the government and society intentions with respect to the education development perspectives are expressed. Based on the corresponding state-social intentions a pedagogical support subject of students training creates perspective-focused conditions of university educational environment. One of the forms of building the given conditions is educational institution development program that is a basic landmark in engineering students learning motivation.

Thirdly, a significant characteristic of educational institution environment directed at students learning motivation is activity-stimulating conditions of university educational environment. The drives of students educational activity are the whole complex of conditions existing in educational institution. They influence the motivation of student's educational activity. Nevertheless, activity-stimulating conditions are formed directly in university educational environment and influence student's activity in various aspects of their life and, first of all, stimulate students' educational activity in socially related directions.

Fourthly, a subject of student's training pedagogical support builds communicative-informative conditions of university educational environment. Information circulating in educational institution is the main source of student's learning motivation in an engineering university. Acquiring it and using in educational activity students promote their personal education – an important element characterizing an educated person. It is obvious that communicative-informative conditions of student's educational motivation are characterized by not only accessibility to information sources. They are to be directly connected with both content of education and methods of a university's academic process (Fig.1).

Engineering student's learning motivation is performed by means of pedagogical support. In the process of student's training pedagogical support every teacher applies not only personal resources, but also united resource of teachers-partners. The consistency of using these resources defines the potential of the group human resource impact on the process of student's learning motivation [3; 8 et al.].

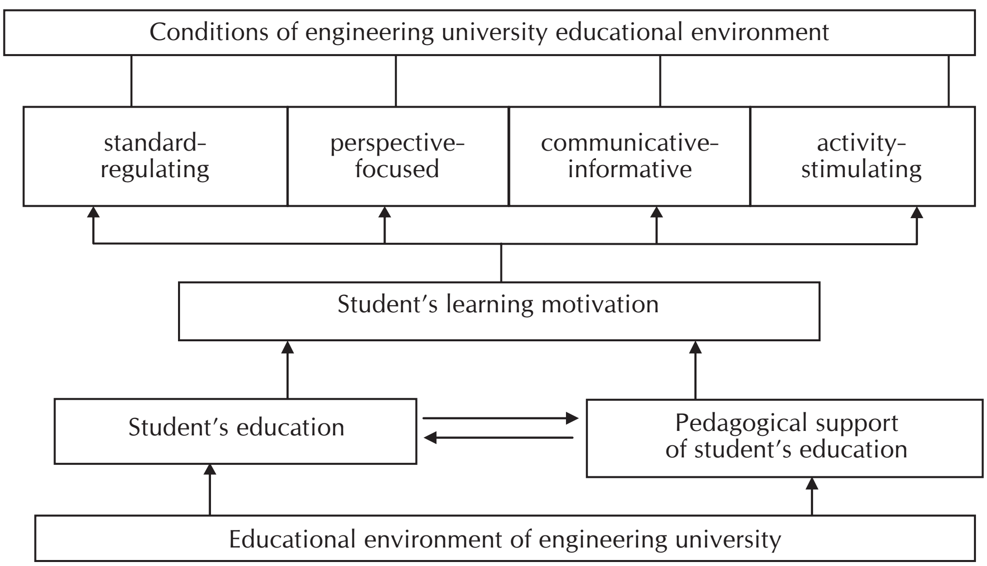
Therefore, one needs to analyze the role of group human resource in pedagogical support of student's training in engineering university.

From the point of view of humanly oriented system-synergetic methodology [4; 7; 11] student's training pedagogical support is manifestation of synergism in professional-pedagogical interaction. According to this methodology a person comes to the fore in relations with his/her environment. Every man is sure to have a specific resource of his existence in the social reality. It is conditioned by a person's features, personal experience, differences in living conditions etc. All these form some general resources which a person can use in his/her life.

Hence, pedagogical support subject of student's training has his/her personal (private) resource. This resource is formed as a result of not only disposition defined by nature, but also developed in social environment (including scientific-



**Fig. 1. Conditions of engineering university's educational environment stimulating student's learning motivation**



ENGINEERING
EDUCATION
13'2013





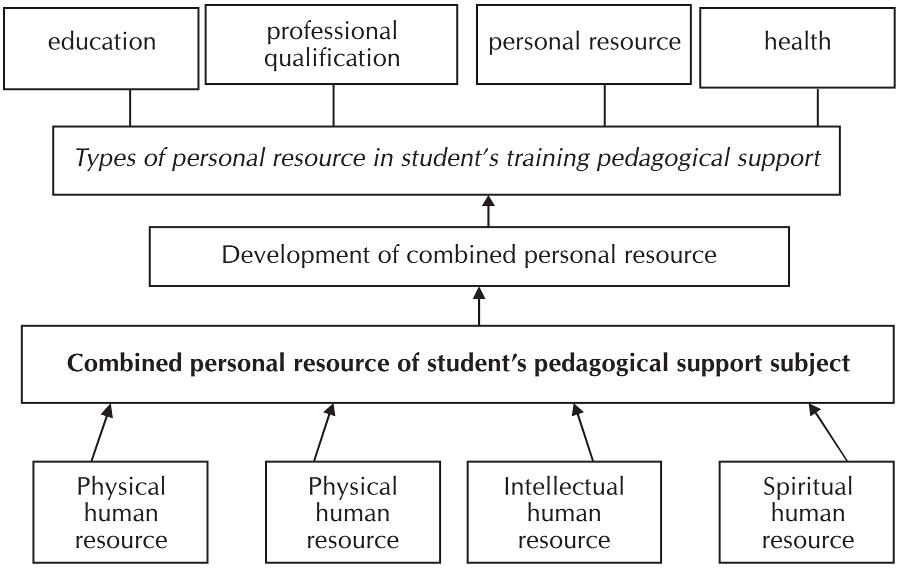
educational process of engineering university). The elements of human personal resource composition are [11]:

- physical resource of a person that is necessary for a subject's pedagogical support life not only in biological aspect but also for his/her self-realization in the university's educational environment;
- psychical resource of a person due to which a subject's pedagogical support of student's training expresses his/her attitude to himself/herself and partners. Psychical resource defines possibilities of pedagogical support subject in self-regulation of relations with partners as well as in management of student's learning motivation;
- intellectual resource of a person that enhance the possibilities of student's pedagogical support subject in self-management and management of student's educational activity. Owing to the intellectual resource, student's training pedagogical support subject is good at efficient actions in the process of student's learning motivation;
- spiritual resource of a person by means of which student's training pedagogical support subject expresses and shows his/her attitude to both himself/herself and partners. By doing so, he/she build up the process of educational pedagogical support in accordance with priority of personal and socially important values.

Taking into account the fact that combined human personal resource is life-long developed, one should note that student's training pedagogical support subject possesses such types of personal resources as education, professional qualification, personal resource, and health [11]. The types of human personal resource mentioned above are expressed in student's training pedagogical support in university educational environment and interrelated to some extend, i.e. using one type of personal resource, a subject of student's training pedagogical support uses its other types explicitly or implicitly (Fig. 2).

Summing up, it should be noted that student's training pedagogical support subject is to apply personal resource constantly as a drive for engineering student's learning motivation. Using personal resource student's training pedagogical support subject takes into

**Fig. 2. Personal resource of student's training pedagogical support subject**



ENGINEERING EDUCATION
13'2013

account student's competences and creates conditions for student's learning motivation. From the point of view of humanly oriented system-synergetic methodology it is necessary for student's learning motivation to be performed in accordance with the formation process of anthropologic-synergetic management, teaching staff and engineering student's community [9; 10; 11]. The given community is a basis for performance of professional competences of teachers-partners, and its activity is directed at quality of engineering student's learning motivation process.

Teacher's concurrence in performing influence student's learning activity is a premise of its efficiency. In other words, student's training education pedagogical support depends definitely on the degree of teacher's concurrence in the process of their professional competence performance.

Thus, student's training pedagogical support can be referred to the key factors influencing the process of engineering student's learning motivation. This process is focused on forming educated people related to socially valuable requirements of society. Integrated indicator of students' training pedagogical support is their involvement in scientific-educational process of engineering university. It means the volume of competences that students perform in scientific-educational process and everyone's application of acquired knowledge and skills.



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UDC 378

# Implementation of Organizational and Pedagogical Conditions for End-to-End Course Project Technology

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**To meet the FSES requirements on competence development in the frame of Bachelor's Degree programs in civil construction it is necessary to technologize a training process and use an integrative approach to course project. The solution could be an end-to-end course project (EECP) technology including the following tools: the structural-logic scheme of the EECP content; EECP procedure; graphical description of the process; the diagnostic tools; the mathematical model of learning activity correction, etc.**

***Key words:*** *interdisciplinary integration, straight-through instructional designing, technologization training, graphic description of technological process, individual profile of student competencies, mathematical model of the correction of learning activity.*

**L.A. Kulgina**

Nowadays, high development of construction industry requires graduates to be able to solve professional tasks on interdisciplinary level, be aware of a whole design process, be qualified in scientific and technical issues of civil engineering as well as be responsive to changes of social demands. Comparing State Educational Standards (SES) and Federal State Educational Standards (FSES) it is possible to conclude that Bachelors should be trained for the same job positions as Specialists but in a shorter period, which requires a valid "phased acquisition of competences". It needs, in its turn, "systematically organized goal-oriented activity" and specified structure of a training process and content [1].

On the one hand, to increase the efficiency of every training stage it is necessary to technologize a training process or "to manage training, ... starting with diagnostics and up to obtaining planned and sustained outcomes of high quality" [2].

On the other hand, we think that it is impossible to develop competences that are actually interdisciplinary without an integrative approach.

Considering that 70% of all required competences of Bachelor of Civil Engineering are directly or proximately connected with designing and the most practice-oriented training form is a course project, we incorporate interdisciplinary integration into the course project. On analyzing scientific literature, course and curriculum content and basing on our teaching experience we introduce it in the form of end-to-end course project (EECP). Unlike the existing guidance papers devoted to EECP our work is focused on pedagogical designing and implementation of EECP technology. It is explained by the fact that it is technology characterized by the following features [3]: goal-setting, predetermined final outcomes, predictive value, possibility for individual learning path, constant feedback, cohesion and completeness of pedagogical process. The previous articles were devoted to the conceptual framework and some aspects of the developed technology while the present article deals with its basic tools.

Implementation of EECO technology includes creating a number of organizational and pedagogical conditions (OPC). These conditions are made by means of some approaches: integrative, systems, process, competence-based and learner-centered approaches (Table 1). This choice is determined by the necessity to consider different pedagogical categories.

The first condition is the EECP implementation in a number of courses. We suggest some modules of end-to-end parallel and sequential course projects that contain from 2 to 8 courses with course projects/works (CP/CW). Grouping the learning materials in EECP modules allows using unified didactic methods based on the following [4, p.33, 91]: module objectives (development of set competences of a particular level); the main component; basic content; general development paths; levels and mechanisms of integration (interdisciplinary connections, transfer, information acquisition in combination with project activities); invariant of integration (natural laws, engineering graphics methods, architectural and construction methods).

To organize EECP in training process the following tools were developed. Semantic graphs are the basic notions of the integrated courses including essential connections and interactions between them (Table 1). They help students to analyze basic structure of the main notions of the EECP module, to organize knowledge they have and to integrate new knowledge in CP/CW more effectively. Interdisciplinary tasks in EECP (2 difficulty levels) built an information base for professional activity and practical application skills for notions of complimentary sciences. Structural-logic scheme of EECP content (Table 1) is based on structure analysis of integrated CP/CWs, understanding of interaction between their elements, transformation of requirements depending on the main goal. It makes the process of EECP fulfillment more rational. The scheme presents different objectives of course project: to identify and diagnose (solution choice from a standard set), to evaluate and analyze (evaluation of complicated systems with different variants of solutions), to combine (use of systems approach). Content description of all stages of CP/CWs is accompanied by project schedule and characteristics of inner- and interdisciplinary connections. It should be noted that the observations show that EECP doesn't exceed structural complexity of the learning material and is less time-consuming in comparison to the traditional approach.

The second organizational condition is a process management (operation) of teaching the courses that are parts of EECP. Regarding quality of educational service as a guarantee of competences acquired by a student [5, p.28] we, as many others, think it is necessary to consider different educational activities in universities as processes.

To create this condition at the department level it is necessary:

- to divide the process of a course acquisition into sub-processes – modules, and determine their sequence in the whole teaching process taking into account their interdisciplinary links;
- to determine the assessment criteria for learning outcomes at the beginning and the end of the courses.

To organize the training process according to the technology it is necessary to develop algorithm for staff and student activities based on designing learning situations and teaching process developed in details. Pedagogical design planning,

Apart from other things, also includes a stage of work decomposition for its better management and monitoring etc. [3, p. 177]. It implies dividing the content of a training process into separate functions [6, p. 24, 56]. We distinguish the following functions in teacher-student joint activities: initialization, planning, performance, diagnostics, evaluation and coordination, accomplishment. Purposive approach was used to determine particular objectives solved in the frame of the function by performing particular procedure and to correlate the objectives with the main goal [3, p. 177]. Morphological approach helped us to choose possibilities to implement objectives of definite functions: 1) resource provision (facilities, data, time, necessary competencies); 2) staff and infrastructure (main participants of training process, facilities); 3) control actions (control data stream: project, design management, restrictions); 4) outcomes (tangible results, data, competencies developed as a result of the project).

The algorithm (Table 1) of the procedures performed by teachers and students in the frame of every function is a sequence of 26 activities including incoming and outcoming documents, alternative solutions, correcting and controlling actions. Graphic description of the technological process of EECP (Table 1) shows the implementation of the above mentioned functions with regard to resources, participants and control actions. It is developed in IDEF0 notation [6], because it is the suitable for description of integration processes, in particular, education area from a department to federal levels. Thus, management of EECP process takes into account initial competence level, the chain of interlinked and cyclically connected functions that ensure feedback for better forecasting, achievement and evaluation of the outcomes.

The conditions for competence and student-centered approaches are regarded as pedagogical ones.

In their learning process students should develop competences of different nature: knowledge gaining, activity, motivation, personal development. They can be fully developed only in the process of quasi-professional activity. EECP stimulates students' interest and independence since they discover many sides of the projected object and are involved in interdisciplinary relations. This fact is also very important for implementation of the competence ap-

**Table 1. Technological means (tools) of EECP**

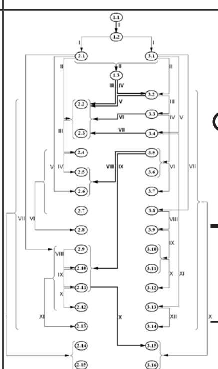
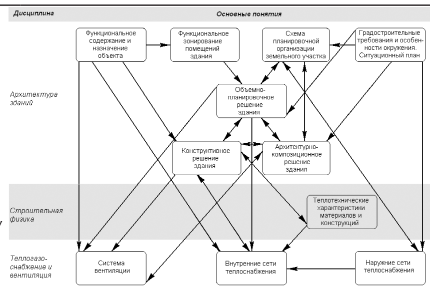
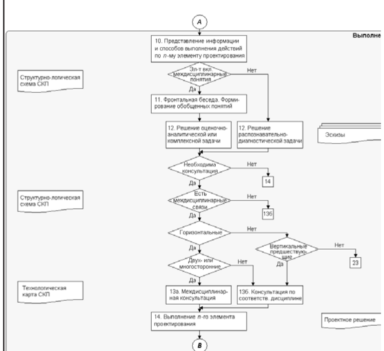
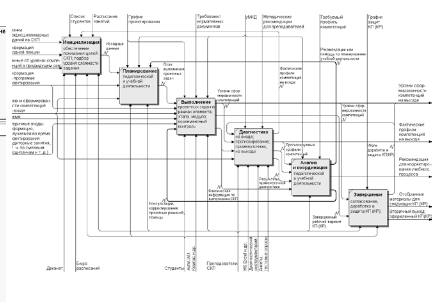
| Approaches | | OPC | Short description of the stages and general view of some tools |
|---|---|---|---|
| Systems | Integrative | EECP implementation |  - Structural-logic scheme of EECP content; elements of projects of integrated disciplines; interdisciplinary connections; inside interdisciplinary connections  - Didactic tools of EECP (interdisciplinary tasks, semantic graph (Fig.) etc.) |
| | Process | Process management of teaching |  - EECP procedure algorithm (fragment in Fig.)  - Graphical description of EECP technological process (notation IDEF0) at the interim stage of Bachelor's Degree programs in civil construction |

**Table 1 Continued**

| Approaches | | OPC | Short description of the stages and general view of some tools |
|---|---|---|---|
| Systems | Competence-based | Reliance on quasi-professional activity of EECP and encouragement of student's independence of developing necessary competencies | (see stage table, list and competence profile below) |
| Systems | learner-centered | Facilitation based on the difference in competence levels, living conditions of students and forecasting their learning success | Math model of learning activity correction in the EECP process, which allows to predict individual competence profiles of students (a) at the beginning of a semester; (б) actual individual competence profile of students at the end of a semester (empirical evidence) |

**Competence-based — Short description of the stages and general view of some tools:**

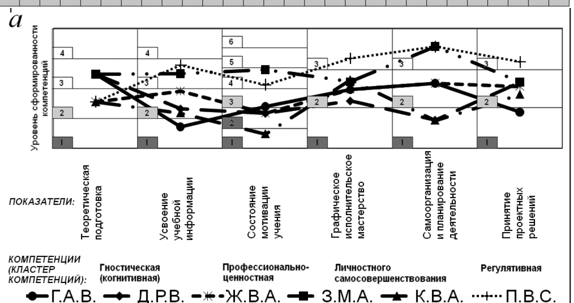
| Смежные дисциплины | Стадии разработки курсового проекта и форма участия преподавателей смежных дисциплин: 1 неделя — Выбор междисциплинарного задания, программа СКП | 2 неделя — Теплотехнический расчет ограждающей конструкции, функциональное зонирование квартир | 3-4 неделя — Разработка эскизов рабочих чертежей, расчет потерь тепла по помещениям | 5-7 неделя — Выполнение архитектурно-строительных рабочих чертежей, выбор и расчет нагревательных приборов | 7-8 неделя — Размещение на планах элементов системы отопления, технико-экономическая оценка проектных решений жилого здания |
|---|---|---|---|---|---|
| ОПД.Ф01.02 ***Инженерная графика*** (2 сем.) | | | | Консультация | |
| ЕН.Р.01 ***Системы автоматизированного проектирования в строительстве*** (3 семестр) | | | Консультация | Консультация | |
| ОПД.Ф10 ***Строительная физика*** (4 сем.) ОПД.В.02.01 ***Основы нормативно-проектной документации в строительстве*** (5 семестр) | | Консультация | | Консультация | |
| ОПД.Ф.11.01 ***Теплогазоснабжение и вентиляция*** (5 семестр) | | | ***Руководство КР*** Консультации | Консультации | Консультации |
| СД.01 ***Архитектура гражданских и промышленных зданий и сооружений*** (5, 6 семестр) | Вводная лекция с использованием междисциплинарного семантического графа | Консультация | ***Руководство КП*** Консультации | Консультации | Консультации |

- technological map (fragment in Fig.);
- diagnostic tools
  (competence skills, description of indicator scales for every competence; competence profile of students, which based on the above mentioned scale);
- diagnostic procedures;
- actual individual competence profile (example in Fig.)

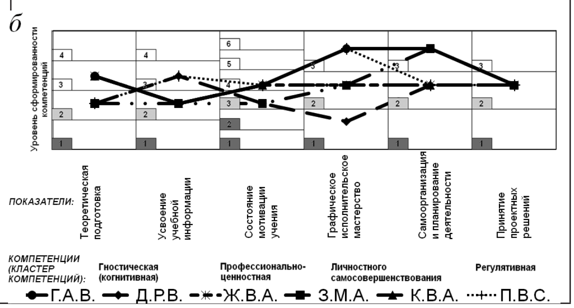

**Learner-centered:**

Math model of learning activity correction in the EECP process, which allows to predict individual competence profiles of students

(a) at the beginning of a semester;




(б) actual individual competence profile of students at the end of a semester (empirical evidence)



proach as it implies the use of complex procedure. That is why the third condition is the reliance on quasi-professional activity of EECP and encouragement of student's independence of developing necessary competencies.

To ensure this condition it is necessary to agree teaching process of allied subjects (courses) in the following aspects: 1) discovering interdisciplinary links of the material for the students; 2) giving information on competence diagnostics.

It is very important to use the time for independent student's work in the most effective way. A technological map (Table) is designed for this purpose as well as for the agreement of EECP design solutions, correlation and distribution of interdisciplinary consultations and further use of the project materials. It is necessary for students to be acquainted with requirements to the learning outcomes and to know what competencies are developed by this or that course, which contributes to student's active and independent position [7]. The use of graphic scheme showing the course's interconnection, current and final learning outcomes and importance of the developed competencies contributes to student's learning motivation and this is important element for student competence evaluation criterion.

Diagnostic tools were developed with the use of psychology and pedagogic science and famous approaches to the competence models used in personnel management that we adapted for students. They increase objectivity in competence evaluation by instructors of allied course. Experimental work includes 6 competence-markers with special indicator scales of development degree level for each competence. These scales constitute a competence profile (Table 1) that demonstrates learning objectives and outcomes[1].

The next condition is facilitation based on different levels of competence development, student's living conditions and forecasting their individual success. In other words, this is the activity focused on encouragement of considered study and help with person's self-development [8, p. 37].

To implement this condition it is necessary to: 1) take into account particular features of acquisition of learning materials of integrated courses, give individual current help to student's with their EECP (especially parallel one); 2) show different project variants for student's independent decision making. Student's challenge in more complicated EECP gradually makes them structure their own experience and be more independent; 3) give adequate difficulty level of a task based on individual approach; 4) distinguish the most independent and challenged students as well as students dependent on opinions of others [8].

Teacher's awareness about student's level of competence development at the beginning of the course (which is necessary for phased competence development and interdisciplinary process management) helps to evaluate the increment of student's skills and competencies at the end of the course. Having this value as well as the desired final competence level it is possible to activate goal-oriented learning and teaching process well-timed. The necessity to take into account a great amount of factors can cause difficulty in forecasting. It can be solved by means of math modeling. Considering I.P. Podlasyy's recommendations we collected data according to 70 productgenic factors and 10 characteristics of learning outcomes for each student of the experimental sample. Math model of learning activity correction in the EECP process is multiple regression equations of the indices showing the

*[1] We think that such scales should be developed for the whole competence model of graduates in specialty civil construction including 13 social and cultural and 23 professional competencies. For correlation with the management models with the optimal number of competencies 8-12 and for better understanding (by staff, outer experts and students) we suggest dividing these 36 competencies into clusters: gnostical, regulatory, communicative, status-reflexive, normative, professionally valuable, personal development and integrative. The requirements to the learning outcomes in different courses (study stages) could be different depending on what competence and to what degree should be developed.*

competence level developed due to the productgenic factors. They are used making forecasting individual profiles of student's competence (Table 1) at the beginning of a term (unlike the learning outcomes at the end of the course, these profiles are not shown to the students). The model scalability is connected with distinguishing factors of successful competence development during EECP and allows coordinating correction activities of instructors delivering allied courses.

Correlating our own experience with the training management principle suggested by N.V. Sosnin [1] (that we consider to be correct) we think that the EECP modules can function as "structure units ... of the super-disciplinary, system-activity type" concentrating "interdisciplinary content, student's personal experience and faculty's activity for organizing training process for development of a need competence". Implementation of EECP technology in a training process will unite instructors of allied courses into a team of the courses content developers who decide together what competencies should be developed and how to do it. The suggested method of diagnostic tools development will help to solve the issues of competence development process rulemaking, learning outcomes registration and correction of student's learning path in the process of competence development.

The experimental work that has been conducted for some years proves high efficiency of the EECP technology in developing design (project) competencies of students and meets the requirements of Bachelor of Civil Engineering training.



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# Educational Process at the Federal University as a Basis to Implement Innovative Practice-Oriented Educational Technologies

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**The article sets a principle goal – to change the traditional system of engineerring education by implementation of flexible practice-oriented and project-based educational technologies by the example of North-Eastern Federal University n.a. Ammosov**

***Key words:*** *educational process, quality management system, data analysis.*

Lack of practice-oriented highly-qualified staff is a burning issue within energy complex: work in the sphere of real economy requires specialists with a certain range of practical skills which are impossible to be acquired at the higher education institute as soon as the letter is strictly oriented to definite educational standards. Meanwhile, industrial and agricultural sectors need the other sort of specialties, profiles, and competences, as a result. In our opinion, it is possible to bring to conformity real economy needs and specialists' training applying special educational technologies, such as practice-oriented and project-based ones [1]. This process is to be flexible and should quickly adapt to meet the requirements of intensively developing sectors of real economy. Today, it's necessary to spend 4 or 5 years to train students within the scope of educational program standards, teaching them primarily theoretical issues and having only 2 or 4 weeks a year spent for practical training. Moreover, present day problems and tasks are presupposed to be solved by a team of specialists of different profiles and educational levels. It can be provided neither by the system of higher education nor by vocational one solely, even if there are all the competences required. That is only the symbiosis of different profiles and levels of education that can contribute to solving tasks in the sphere of innovations and advanced technologies.

The system of highly-qualified power engineers training in Sakha republic (Yakutia) is unique because the students who are not great in number but taught within a wide range of specialties (profiles) acquire knowledge not only about technologies of producing, transporting and distributing electric power but also of north regions' particularities. The important thing is that there should be a special system of specialists training directed to getting proper practice- and project-based education, efficient refresher courses and continuing professional education [2, p.12-13]. This uniqueness also makes it necessary to achieve breakthroughs in industry and agriculture of the Extreme North.

The system of practice-oriented and project-based education is supposed to aim at working out new educational standards and, as a result, new educational programs based primarily on professional standards. Moreover, there should be special environment to build and develop professional competences essential for corporative and international work [1, c.10]. It will contribute to overcoming the barriers between real economy (business) and higher education institutions.

The problem of power engineers training is not only an issue of power engineering sector but also a great challenge for the whole economy which lacks highly-qualifies specialists. A power engineer should also know particularities of different industries, public systems, agriculture etc.

In our point of view, the most effective environment to train power engineers at North-Eastern Federal University (former Yakutsk State University n.a. Ammosov) has always been that of Student Educational and Scientific Laboratory "Energy" (SESL). For students SESL became a prototype of future professional and social activities [3, p. 36-39].

An essential function of SESL is continuous development of student that implies gradual shift from school instruction modes typical at the beginning to the advanced learning activities relevant to professional and social activities. As a result, students who worked on 1 or 2 mutual projects turned out to be involved into interpersonal and team relations [1, p.11].

The students of SESL are taught not only by teachers but also by influential scientists of Yakut Scientific Center of the Siberian Branch of the RAS, Larionov Institute of the Physical-Technical Problems of the North of the Siberian Branch of the RAS. There are also top managers of some companies such as "YakutskEnergo" PC SC and "SakhaEnergo" PC where students solve not only scientific tasks but also real industrial problems. Thus, students gain necessary experience within their profession.

This educational environment produced its results.

The students of SESL became prize-winners of Lavrentyev competitions, got diplomas at Russian and International conferences; students' diploma projects were the best at The Competition on Diploma Project of The Russian Federation, section "Power Supply". Last year three students got scholarships of the Government and the President of the Russian Federation, the other three students became laureates of V. Potanin Scholarship.

The next stage of energy education in the Republic was creation of educational platform for engineering [1, p.10] to teach students power-supply system modeling. It was Student Innovative Planning and Design Office (SIPDO).

Creation of SIPDO and SESL which dealt with development and implementation of innovative technologies in energy saving let the department win a federal grant for the innovative educational project "Education-Science-Production Complexes to train priority sectors specialists for economic and social improvement of North-Eastern Russia" within the lot "Energy saving technologies implemented into industrial and public infrastructures of North-Eastern Russia throughout educational process". The aim of the project was achieved – they laid down the foundations of innovative system of training highly-qualified specialists who are in demand at regional labour market and who are competent in power supply and resource-saving systems of northern regions.

Applying practice- and project-based technologies and involving students into problem solving [1, p.12] one should be aware that the projects students work on, first of all, are real and in the second place, are innovative and of breakthrough nature. Only such active teaching methods can make students create real projects anticipating professional activities.

The competence of teachers who work with students is determined by the quality of engineering activity products including those produced in cooperation with specialists of industrial, scientific and research sectors [1, p.13-14]. Implementing standards 9 and 10 of CDIO teachers of NEFU in cooperation with St. Petersburg National Research University of Information Technologies, Mechanics and Optics, manufacturing enterprise CJSC "Optogan" and Weihenstephan –Triesdorf University of Applied Science, Faculty of Horticulture and Food Technologies participated in the competiton according to the Decree of the Government of the Russian Federation № 218 "On measures of governmental support for cooperation between Russian higher education institues and organizations implementing complex projects of high technology production" of April, 4, 2010.

The mutual project "Intelligent systems of energy saving greenhouse agriculture with the use of LED lighting" was approved in 2013 and received financial support for the next three years. Working on this progect one can not only regard the sharp issue of greenhouse agriculture with the use of modern energy saving technologies but also demonstrate the algorithm of team work to carry out breakthrough projects to students, undergraduates and postgraduates.

The project aim is to develop energy saving intelligent greenhouse systems on the basis of high-power LEDs usage. Innovation of the project is caused by three reasons: 1) multi chip-on-board LED lighting with original emission spectrum; 2) module principle of lighting that supplies light for different planting systems (upper supplementary lighting, inside cenosis supplementary lighting, multi-level systems of lighting etc.); 3) multi-protocol management of lighting and climate-forming equipment applying adaptive algorithms.

The main target of the project is to increase energy effeciency of argiculture greenhouse production. Taking into account the fact that Russian greenhouse enterprises are planned to be multiplied by 2,5 within next five years the project is expected to contribute to global energy saving in agriculture of Russia thus improving market competitiveness of Russian agriculture products.

The project work at NEFU is provided by six groups of students, undergraduates and postgraduates of four university institutes: Institute of Physics and Technologies, Institute of Mathematics and Information Science, Institute of Engineering and Technologies, Institue of Natural Sciences working on particular aspects within one complex project under the direction of university teachers and specialists of industrial enterprises. At the very beginning of work it turned out to be necessary to create an interuniversity lab in cooperation with CJSC "Optogan" and the department of the University. Taking into account regional peculiarities of the Republic, hardly predictable market demand in specialists and lagging educational response to the market situation, such department is considered to be able to react to enterprises' needs training undergraduates for the specialties in up-to-date regional need. It's obvious that these highly- and narrowly-qualified specialists are to be few in number but be easily recruited.

There is another important problem that is solved while working on this complex project is that of practice-oriented and project-based educational technologies implementation [1].

The principle target is to change the traditional system of engineering training. It is necessary to create efficient and flexible practice-oriented and project-based educational technologies which will provide continuous training starting with vocational education, then passing to higher professional education and turning to professional standards. The task can be solved only if top managers of both real economy and educational sectors are particularly interested in the enterprise and eager to develop and implement new forms of business and state (federal) education interaction following project-based educational programs.

To make a conclusion, innovative practice-oriented and project-based educational technologies are implemented in the most effective way while working on breakthrough projects carried out by students, undergraduates and postgraduates in cooperation with university faculty and real economy specialists supported by the government.

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UDC 811

# Approaches and Methods for Motivation Development at University

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**The article deals with pedagogical technologies, innovative approaches and methods of work with students, motivating them to be engaged more in the training process.**

***Key words:*** *motivation, anthropologists oriented, modular technology, productive, creative methods.*

**L.M. Semenova**

Modernization of the Russian system of professional education is determined by updating and improving of approaches and methods aimed at developing students' motivation in studying. Learning efficiency largely depends on the level of students' motivation to study.

From psychological findings we know that people are motivated by values, needs and requirements. There are two types of motivation: intrinsic and extrinsic. Intrinsically motivated students learn new things within the studying process. These students are observant, curious, receiving inner satisfaction when discovering something new. Extrinsically motivated students need approval for completed task. Most students are motivated by a combination of internal and external influences.

Pedagogical practice shows that often it is required to encourage students to study, to orient them to achieve a certain result, maintain their energy and perseverance, to assist them in overcoming apathy, tiredness, etc.

To solve this problem we should apply some technologies, approaches and methods for developing not only cognitive motivation, but professional motivation as well: anthropo-oriented, modular, game-based, productive, creative.

Anthropo-oriented technologies are a synthesis of structured methods of organizing seminars, video training, discussions, mini-conferences using process visualization capabilities and technical resources, respecting the equality of all members of the university integrative learning space. Anthropo-oriented technology is designed so that students have more opportunities to influence the choice of discussionquestions and training content. According to L.L. Redko, their objective binary facilitates the acquisition of knowledge about the norms and attitudes, rules and prohibitions, as well as the skills they use in their professional activities. [1]

Anthropo-oriented approach in training allows to focus on a person as a basic value, the learning objectives, with access to integrity and balance of individual aspects of personality development; focus on natural characteristics of a person, his spiritual development.

Below you will find examples of such technologies we use in teaching practice.

ETRI Technology (Experience – Tactics – Reflection – Implementation) is used for small groups interaction. This technology is implemented according to the following algorithm.

1. Experience. After receiving a task, a small group shares experience

on the problem between each other involving all members of the group and collects a "bank of initial data".

2. Tactics. Correlating the problem and "initial data", a small group develops tactics (finds a way) to solve the problem and "approves" (tests) the decision.

3. Reflection. Test results and ways used to achieve them are evaluated. Participation and personal contribution to the "product" of group interaction is required.

4. Implementation. On this stage should be created the strategy how to implement the developed model of interaction in a small group to solve the stated training and identical (but real) problems. If needed a real professional situation could be played out.

It is important to note, that each stage of model realization may be broken down into smaller steps using the same ETRI technology.

Panel discussion on current issues of professional activity involves highly skilled experts who share their opinions on the matter. Panel discussion – a modern form of work with the audience, with maximum level of interactivity and dynamism. Recognized practitioners, theorists and teachers are invited as keynote speakers to set the pitch. Their reports and well-reasoned ideas are attentively listened and followed by discussions. Not only students but all stakeholders are involved in discussion.

During the lecture, you can activate the mental activity, draw interest to the training material, thereby increasing the motivation to learn. This is achieved by special techniques and methods based on the concept of problem-based learning. These methods include lectures-conversations with questions to the audience, joint conclusions and certain provisions making based on the studied material, brief overview and discussions during the lectures, etc. In modern didactics discussion principle of new information presentation came into practice in the form of problem-based learning, when making independent research students themselves find solutions to any problem. At this kind of classes students learn how to communicate, act as opponents and find arguments within discussion. Conversation is a dialogue between teacher and students. During conversation the teacher develops student's ability to make their own assessment of current events, opinions and positions. Interactive nature of conversation provides the motivational sphere of influence on the student's personality, stimulates cognitive interest.

Lecture-press conference. Indicating the topic of the lecture teacher asks students to make written questions to him on the issue. Within two to three minutes most students formulate their questions and pass them to the teacher, who has about three to five minutes to sort questions on their content and begins the lecture. Lecture is made not in the form of giving the answers only, but as a coherent text including the answers.

E-learning tools also act as a motivating factor in the university practice.

Multimedia technologies in training suggest a set of modern audio, television, visual and virtual communications implemented for educational activities. In line with our experience, this method is efficient during lectures and workshops and helps students to make multimedia presentations.

Video training – a social-psychological training, which actively use modern tools to work with the video in order to improve the efficiency and success of training.

Video training – is a peculiar form of work where the student exercises are recorded, followed by parsing and correcting their behavior. This method allows future professionals "form" parts of their behavior, adjust them, to develop a new model of communication and behavior. Video training is one of the main methods of conducting practical training and develop useful skills. Formulation of problems in the training may be different, but not necessarily related to the acquisition of knowledge, the formation of skills and behavior correction.

Video training relates to advanced technology training and information transfer to ensure maximum efficiency and minimum cost.

Thus, the anthropo-oriented technologies help to encourage students be more active during the classes, allow to show greater independence, contribute to the acquisition of knowledge and skills and apply them in their professional activities.

Modular technology involves distribution of educational discipline problems on certain components (each topic can be studied at one level or another: a general introduction to the problem, in-depth study and decision-making methods, special approach to problem solving the based on their own choice and justification of actions).

Modular technology is based on the following idea: a student learns independently and a teacher manages the studying process: motivates, organizes, coordinates, advises, monitors. The essence of this principle is that a student independently with the support of the teacher achieves specific goals of educational-cognitive activity in the course of the module. Module is considered to be the target functional unit that combines content of the training and technology of knowledge acquisition in high-level integrity.

What is the main difference of modular technology from other training systems?

First, the learning content is presented in complete independent complexes (information blocks) and their studying is carried out in accordance with the purpose.

Second, changing the form of communication between teacher and students. Training is provided through modules and private, individual communication. This kind of training modules allow to make transition to the subject-subject basis.

Third, increasing the maximum amount of time students work independently, learn how to plan their activities, promoting self-organization, self-management and self-esteem. This enables them to test themselves acting and determine the level of knowledge and skills development, see gaps in their knowledge and skills. Teacher also manages the educational-cognitive activity of students through the modules, but it is softer and highly targeted type of management.

Fourth, the presence of modules with printed handouts allows teacher to make work with the students more individual. No need for individual counseling.

When implementing modular technology we followed certain rules:

1. Before each module (except the first one) entrance control of student's knowledge and skills should be done in order to get information about the level of their preparedness to work on the new module.
2. If there are any gaps in students' knowledge the proper correction should be foreseen.
3. Interim and final control at the end of each training element (self-control, mutual control, reconciliation with the sample) should be provided. Current and intermediate controls are intended to identify gaps in learning to address them directly within the training.
4. After completing the module final control is foreseen to reveal the level of module learning outcomes achievement.
5. If the final test shows a low level of understanding and lack of skills, then the revision is needed.

Implementing modular technology in our pedagogical practice, we came to the following conclusions.

Modular training engages each student in active and efficient training process and cognitive activity, working with differentiated content program. It implies individualization of control, self-control, correction, counseling, certain level of independence. It is important that students get opportunity for larger self-realization that promotes learning motivation. This training system ensures each student mastering educational standard and promotion of higher education level. Described technology assists in development of personal characteristics such as student autonomy and collectivism.

Teacher position in the training process also changes dramatically. First of all, the changes refer to its role in this process. One of the main tasks of the teacher is to motivate students in managing their learning and cognitive activity and to consult them. Certain changes of teacher's activities within the training have an impact on his/her preparedness for the classes. In this case, the teacher is not preparing how to explain the material better, but how to manage the activities better. Since the control is carried out mainly through the modules, the task of the teacher becomes to make competent separation of module integrative didactic purposes and structure learning content for these purposes. This is a fundamentally new way to prepare for the teaching and training process. And of course it leads teachers to the need of making analysis of their experience, knowledge, skills and searching for better technologies. Planning learning objectives and learning outcomes, definition of the program activities, awareness of possible difficulties, clear definition of the training forms and methods furthers the teacher in understanding their students better.

Game-based methods also work with students and motivate them to increase interest in learning.

Application of business and role-playing games has a special significance for the formation of managerial and organizational thinking of future specialists. Games imply living modeling of training process. Participation in such games allows students not only to understand the basic principles of production process, but also to acquire professional skills. Business game is a form of simulating the objectives and social features of their future professional activity.

Remaining one of the forms of pedagogical process, educational business game is recreating the context of the future work in its subject and social aspects. In a business game students perform quasi professional activity that combines studying and professional elements. It allows them to develop required competence – interaction and management skills, collegiality, ability to lead and subordinate. Such games bring develop personality, facilitate the process of adaptation to the profession.

Business game is implemented in a dialogue mode of communication and focuses on two types of goals: role-playing and teaching.

Active, productive and creative method for has proven their efficiency in student's motivation in the modern university practice. They aim to promote student's interest in the development of creativity, and increase the level of activeness. Intensive methods implemented in pedagogy are aimed at achieving better results in less time. Some of these technologies are broadly used in our university.

One of the efficient tools for studying motivation is a "brainstorming" or an intensive search for solutions. It is an organized process of generating ideas through open and free of barriers discussion. Brainstorm starts with the selection of the topic or problem. The instructor asks each person to express his/her opinion. But the criticism is not allowed. When there is a lack of ideas stimulating questions are required. The ideas must be recorded on the board. Then some of them are chosen from the list, discussed and ranked. Finally, a majority of votes determine one or two most progressive ideas that need further development and implementation.

This method is used as a way to obtain a large number of ideas from a group of students in a short time. An advantage of this method is that the teacher can encourage participants to use their imagination when thinking of ideas. The main features of the method are as following:

- Teacher asks students to express their ideas, no matter how incredible they may seem;
- Qualitative assessment is not made;
- Obtaining the largest possible number of ideas, not rejecting anything;
- After an intensive search for solutions selection and evaluation of all ideas is made;
- Analysis of all possible solutions.

Another way to motivate students could be team-working.

Work in small groups – trade unions. It implies division of a large group into small ones, working in different parts of the classroom. The method facilitates communication in the group and fits different types of training. When applying this method teacher must:

- Clearly explain the task and the roles;
- Analyze students' answers within the training process and ask questions;
- Include other groups in the report.

Work in pairs. To implement this method teacher asks a question and then students have about five minutes to think about the answer. Advantages of this method are as following:

- All students must share their opinion – a pool of ideas is ready;
- More reliable comparing with a full group;
- Can help to get in contact at the beginning of classes.

Intensifiers and uniting exercises. As a rule these are short and funny games and exercises that promote better acquaintance and close cooperation. They are usually used in the first studying years, however one can address to them any time if students started to form groups. Such exercises can help newcomers feel more comfortable and get to know each other. Intensifiers help:

- to animate the group after long or difficult classes or after the break;
- to draw the group's attention if the teacher reveals less interest in other activity or subject;
- to immediately switch the discussion to another topic, to avoid conflict.

Case Study (Case analysis) – an effective method of motivation in the classroom environment. It allows you to add items to the problem-based learning. Students not only have opportunity to update previously acquired knowledge, but also to actively get new skill and develop them. Of all the diversity of illustration, example and estimation situations within the educational process the main emphasis should be made at problem situations. The situation in the communication process, containing a problem that requires professional decision – the so-called problem situation. It allows to develop ability to identify the main problem, determine the objective, properly formulate the task, identify the symptoms of problems, develop methods for solving the problem, which is particularly important for the specialist in the field of public relations.

Basket-method is based on the principle of throwing ball to the backboard during the sport training. Also students should actively suggest proposals on the discussed issue and the teacher writes them on the board. Then comes the turn for discussion, choice of the most efficient ideas and their positioning according to the rating results.

Diary, as noted by V.G. Bogin, M.V. Zyuzkov, Y.M. Orlov [2, 3, 4] it is one of the most useful tools for learning and self-development. That is why we consider it as a tool of motivating students to work independently. We offer three types of student's diary.

"Reflections on Me" – a kind of diary intended to fix in it:

- Own findings, the results after performing special exercises aimed at analyzing a day, a week, a month;
- Summaries of reflections on various topics;
- Self-characterization notes.

"Success map" – a peculiar kind of diary in which you want to record only the positive results of the activity (i.e. successes) per day.

"Diary of professional growth of future specialist" – a kind of a diary, where the future specialist captures the level of development of his professional abilities and skills, including the culture of appearance, the culture of communication, language culture, culture, self-regulation culture.

In conclusion, we would like to note implementation of these methods, approaches in pedagogical practice increases student's motivation. And student's motivation is one of the most efficient ways to improve the training process.

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# Activities-Based Teaching to Build Environmental Competence of Students

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**The article presents the analysis of various definitions of the concept "environmental competence", which were suggested by different authors. The author of the paper suggests a new definition of the concept "environmental competence". The matter of activities-based approach has been revealed. The basic methods to apply activities-based approach to build environmental competence of students have been described.**

***Key words:*** *environmental competence, activity approach, active learning methods.*

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The government papers on higher education modernization set the goal to improve specialists training. The Government Strategy of Russian Professional Education declares competence approach to be applied and thus the educational goals to be reconsidered. The main objective is not to provide students with certain amount of knowledge within the scope of curriculum but to enable a specialist (or a graduate) to adapt to different conditions and to act under various life, professional and problematic circumstances. The main result of education modernization is to make a graduate be able and ready to bear responsibility for both personal and social welfare and become professionally competent [6, p. 1–10].

Any professional activity implies interaction between a human being and the environment. Environmental incompetence undermines the foundation of human society and ecologically sustainable development. As a result, it is quite important for a specialist to be competent not only in the sphere of his/her professional activities but also in environmental issues (V.M. Kalinin [19]).

The concept "environmental competence" first appeared in science and social and political spheres in the second half of the XXth century. It was brought into scientific use by a soviet cultural studies scholar L.N. Kogan and his work "Environmental Competence of Developed Socialistic Society". The ideas of this work were reported by the author at the conference "Ideological and Theoretical Problems of Scientific and Technological Advance" (June, 1973, Sverdlovsk). Then the concept was developed in different branches of knowledge: ecology, psychology, pedagogics, ethics and cultural studies.

Particularities of environmental competence proper were studied in few psychological and pedagogical works by L.S. Chopenko, A.R Eferova, I.D. Zverev, V.I. Tomakov, E.V. Muravyova, N.F. Kazakova, L.E. Pistunova, D.S. Ermakov, A.N. Zakhlebny and others.

What is important, the content of the concept "environmental competence" is not the same being used by different authors and varies in matter and functional aspects. Principal differences are represented in Table 1.

Having analyzed the definitions given by different authors we have driven to the following: environmental competence of a modern specialist is an ability to apply timely and effectively the knowledge and experience got in the professional sphere to save and improve the environment, to solve and prevent environmental problems competently, to be ready for changes in

ENGINEERING EDUCATION 13'2013

production. To make all these qualities true it is necessary to build environmental competence of future engineers while they are studying at university.

Within the system of ecological education special attention should be paid to pedagogical techniques (or teaching methods) being used to increase the level of knowledge about environment, to improve environmental awareness and to develop environmentally important personality traits (environmental responsibility) of adolescents in present ecological situation in the world, country, and region [8, p. 154-159].

Today, the development of pedagogical techniques is greatly influenced by activities-based approach to teaching, the idea of which is not to transmit the information but to make students get knowledge in the result of their own educational activities directed to learn the subject theory and the ways to solve the relevant tasks. Knowledge is acquired and displayed through activities only; development of student abilities and skills is based on the action which should be performed by the student independently in the right way (mode). In the process of teaching and learning basic educational actions make up the entire circle of educational activities: apprehension, comprehension, memorizing, summarizing and systematization of any information item to be learned, as well as further control and assessment [4, p. 14-15].

Within the scope of activities-based approach to exploration and organization of educational process the aim of the activity is a set point and is regarded as



**Table 1. Definitions of the Concept "Environmental Competence"**

| Author, year | Definition of concept |
|---|---|
| L.S. Chopenko, 2007 | an integrative personal quality which conditions the ability to interact within the system "man – society – nature" according to acquired ecological knowledge, abilities and skills; beliefs, motives, ideas, environmentally important personal qualities and experience in environmental activities. |
| A.R Eferova, 2010 | a personality trait of an engineer represented by the unity of his/her theoretical knowledge, practical experience, ability and readiness to professional conduct which satisfy production, health and safety requirements, provide the necessary health level, personal and social safety and environmental safety of habitat. |
| I.D. Zverev, 1995 | an individual characteristic reflecting the degree of individual conformity to the requirements of environmental education: cultivating in students environmental knowledge, abilities and skills intended to develop environmental awareness, thinking and world outlook which are necessary to pattern one's behaviour under a certain ecological situation, to remove or limit environmental risks. |
| V.I. Tomakov, 2007 | a personality trait of an engineer represented by the unity of his theoretical knowledge, practical experience, ability and readiness to provide all professional activities which satisfy production and health and safety requirements, provide the necessary health level, personal and social safety and environmental safety of habitat. |
| E.V. Muravyova, 2008 | to know fundamental laws of nature; to understand that these laws are necessary to be considered and to follow them conducting individual or collaborative activities; to tend to optimal nature management for private and production purposes; to arouse responsibility for nature, environment and public health. |
| N.F. Kazakova, 2001 | an integrated ability consisting of values and motivation, activities and cognitive components making the foundation to create environmental culture of a personality. |
| L.E. Pistunova, 2006 | a personal characteristic including the knowledge about natural environment is of great value, about the way the man influences the environment and how he interacts with it; being creative while being trained to solve ecological problems; experience of participation in activities to save and improve the environment; environmentally important personality traits of a student like being humane, emphatic, economical, responsible for the results of environmental activities. |
| D.S. Ermakov, 2008 | being aware, able and ready to conduct environmental activities on one's own; experience in the activities directed to saving and sustainable reproduction of life, environmental improvement while identifying, solving and preventing ecological problems. |
| A.N. Zakhlebny, 1997 | application of knowledge about environment and human activities, environmental health risks and abilities to behave in an environmentally competent way under certain circumstances |

anticipation of the activity results. As a matter of fact, the function of the aim is to direct the activity.

The main techniques of activities-based approach are exercises (tasks), laboratory and practical methods, active teaching techniques and role plays [4, p. 26].

Let's give some examples how to apply the activities-based approach to build environmental competence of students.

Active teaching and brining-up strategies are those of interaction. The techniques being used make student's activities productive, creative and searching; they encourage student's activities and presuppose free exchange of opinions on different ways to solve a problem. Among active teaching techniques one can differentiate between conversations, debates, seminars, business games and trainings. Any active teaching technique presupposes group training and a certain procedure to follow [1, p. 50-58].

Communicative and business games involve students into the system "man – society – nature"; familiarize them with the causes of ecological crises and possible ways to restore lost balance of the system; develop environmental competence, environmental mentality, environmental awareness and responsibility. Playing training games is the best way for a student to become psychologically ready for real ecological situations; to understand the ways people of different social roles treat the environment and how it is connected with the professions they have and the positions they occupy; to acquire communicative skills to interact with people of the same age. Association-driven games emphasize the importance of environmental knowledge; develop student's potential and emphatic abilities; determine student's cultural and social values; create the feeling of community and interaction with nature as the most important part of the environment; enrich inner and moral experience of the youth. Role plays give an opportunity to try oneself in various social roles; encourage a student to be effective in different ecologi-

**Table 2. Groups of Educational Tasks Necessary to Build Environmental Competence**

| № п/п | Educational tasks necessary to build environmental competence | Content of educational tasks necessary to build environmental competence |
|---|---|---|
| 1. | Theoretical tasks | include questions, exercises, tests or computer programs, text to analyze and discuss a certain ecological situation. The tasks are directed to develop environmental mentality and make youth environmentally aware what presupposes profound and scientifically grounded understanding of interaction between the human being and nature, the abilities to analyze facts, find out cause-and-effect relationship and take proper decisions.<br>The tasks dwell on chemical contamination of the environment (sources of contamination, way of getting into the biosphere, the influence on ecosystems and organisms, the cycle of matters, habitat deterioration), creation of low-waste and environmentally friendly methods to save human health. |
| 2. | Calculation-based tasks | contain information on quantitative assessment of chemical and environmental processes. These tasks facilitate awareness of environmentally friendly chemical technologies being invented and implemented, natural resources and energy being optimally depleted; present the methods of waste disposal and processing; let assess the scale of contamination and estimate the state of environment using such indicators as MPC, amount of waste per tonne of production. |
| 3. | Experimental tasks | tend to be exploratory. An experiment makes it possible to master the simplest methods of environmental exploration and control, the ecologically friendly ways of dealing with chemical substances. An experiment can be closely connected with modeling or imitation of environmental, anthropogenic or technological processes what encourage thinking and contribute to experimental investigation, develop practical skills. Doing such tasks youth learn to make conclusions by their own what is fruitful both in practical and theoretical aspects. |
| 4. | Combined tasks | are complicated tasks as soon as to solve them one needs to analyze the problem from the theoretical point of view, conduct an experiment and make calculation on basis of the results that were got. As a rule, combined tasks tend to be exploratory and forecasting. They are appropriate for group work. |

cal situations; make a student interested in adequate assessment of his readiness for socially important actions; develop the abilities to analyze the actions performed in the environment by himself/herself or by another member of the society, to act in an adequate way in future social and ecological situations, and to aim at accomplishment in social sphere. The main method of teaching in a role play is to develop the skills of rebuilding and regrouping concepts, ideas and facts not to give an educational reply but to response in the way essential for the person whose role is being played. Communicative games help to develop communicative abilities, build up environmentally competent speech and improve social skills; to cultivate the culture of communication and develop the abilities of interaction; to train the youth to pattern their behavior under different ecological situations. Activity games teach students to be aware of the importance of nature in human life, encourage them to participate deliberately in environmental activities, develop the ability to work out social skills using environmental knowledge and experience they have acquired, provoke need for success and intention to self-actualization; create circumstances under which students get social and environmental experience in connection with inner and moral aspects [9, p. 20-40].

Within the scope of environmental education V.M. Nazarenko points out four groups of tasks necessary to build environmental competence: theoretical, calculation-based, experimental and combined (Table 2).

Depending on the function they fulfill, tasks on environmental issues can be split up into three groups: 1) tasks which provoke interest for environmental problems; 2) tasks which contribute to building students' personal traits (being hard-working, responsible, diligent, and an effective team player); 3) tasks which make a student take a moral choice thus revealing the level of his/her environmental mentality [8, p. 154-159].

To make a conclusion, using these methods (tasks, active teaching methods, role plays) one applies the activities-based approach to education. Students acquire knowledge and skills which will influence their future professional conduct.



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# Quality Management of Project Development Process

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**Based on performed analysis concerning the notion "project development", quality determination criteria of design products, classification of projects designed in universities and possible quality management tools applied in the project development process, application requirements are proposed for specific sub-processes with further operations manuals.**

***Key words:*** *engineering, project, quality, process, control, management instruments.*

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Nowadays, Quality Management Systems (QMS) are steadily growing, which, in its turn, increases the competitiveness of this or that organization. However, in many cases, the development and certification itself resolves into a designed quality document pack, but now, it can be urgent to document QMS so that it is "transparent", i.e. to verify documentarily (in written form) that this System should not only exist, but mainly, it should function. That is why one should not pursue to build non-demanded documents, but to build such documents which would become either "reference books" or "pocket books" for many executives.

Product Lifecycle (PLC) includes such a stage as "Project Development"[1] which, in its turn, is closely related to the term "project" and embraces two meanings: as a result and as a process, including project development. These two meanings are schematically depicted in Fig. 1, where "project development" is highlighted as a dot-dash line. The target of project development is to carry-out the requirements as to the new product or service, specified by the consumer, or specified by normative-technical documentation, or revealed as a result of Marketing Study.

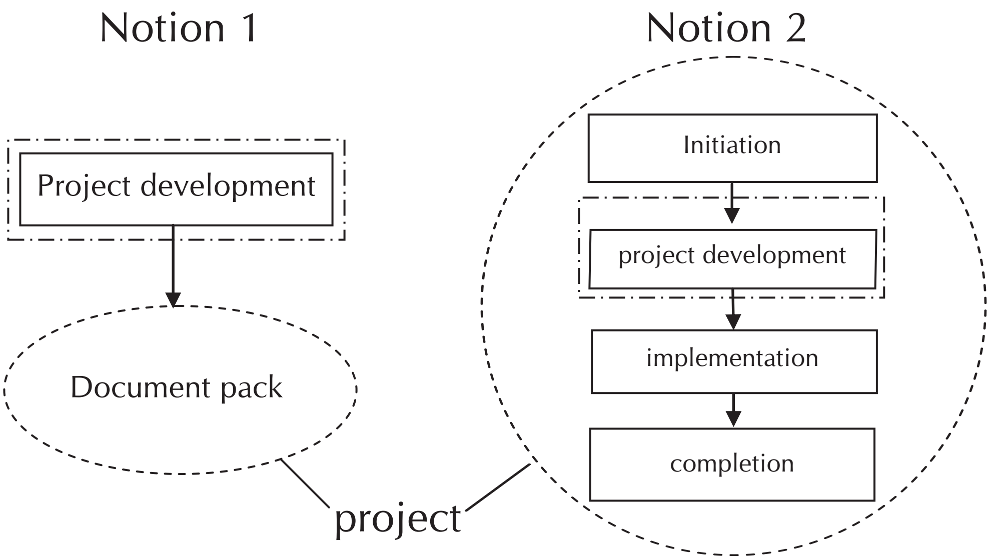
Project development is an integral part of any institution, including educational ones. Project development activities and curricula designing are based on the following: analysis of statistic reports in market expectations of education services, and perspective regional development plans, enquiry letters from employers, feedback of university graduates, as well as assessment of university procurement management, human resources and information support. Process results involve the designing of teaching and learning aids facilitating the training of students, Bachelor and Master degree students in specific specialties and qualifications.

Projects are classified in accordance to different attributes (in brackets examples for NAFU):

1. Type:

- technical (project in construction of training-laboratory building )
- organizational-technological (project in implementation of new management system; conference management);
- economic (project "Students-SberBank", within the framework of

**Fig. 1. Diagram of the term meanings "project"**




which students of NAFU and REFEI represent their projects concerning consumer loans, propose new service ideas and methods in improving bank office service quality);

- social ( project in increasing the amount of academic scholarships);
- combined.

2. Category:

- mono-project (projects in designing curricula of different specialties and qualifications, course wares, including discipline programs);
- multi-projects (project in university reformation);
- mega-project (project in developing Barents Island region in collaboration with NAFU).

3. Duration:

- short-term (design-project of university hall);
- mid-term ( (project in building student campus);
- long-term (development project of Barents Island region).

4. Organization level:

- internal (projects in quality improvement of organization);
- external (project in developing contract-based project organization).

5. Mode:

- investment (university development project);
- innovative (competition of youth innovation projects KUMIR, student competition "Scientific- innovative projects to develop new types of effective business activities", education project "CanSat in Russia");
- research (unique project-"Floating University": student training laboratory within marine expedition);
- academic ( term and diploma projects);
- combined (projects within the framework of European Union-Russia cooperation programs, including "Cold-Arctic- European Neighbourhood Partnership Instrument ", "7th Framework Program in Research and Technological Development of European Union; 2007-2012" "TEMPUS").

Practically, all activities in organizing the process and further assessing the quality of project documentation and decisions are relevant to the project executive competencies (i.e. manager, chief project engineer and others) who frequently take on several projects simultaneously. However, it should be noted that the most significant problem is the existing confusion in project development results of different specialists, functional areas and even project organizations.

Most commonly, the quality of project documentation itself is analyzed either when submitting it to the customer or during expertizing. However, issues concerning quality should be highlighted throughout the project development process and so executing the monitoring of the project itself. In this case, the quality of the project product is restricted neither to the observance of normative documents and project development duration-period, nor compliance with the standard requirements of unified design documentation system. In many cases the quality of the project documentation is considered from the point of view of the number and significance of reclamations from customers, producers and organizations operating this or that project product. That is those discrepancies should be worked out and worked at. In view of this it is vital to apply quality management tools which have been described in numerous publications [2]. Although, there is a lack of explanation in the question: how to apply these tools. There arises the question: "We have plotted the diagram, further what?" This is the issue that must be carefully examined and analyzed as it further would show how to apply this or that tool. Considering the sequence principle identified in the Deming cycle (PDSA: plan-do-study-act), what tool should be applied in what process is determined and proposed (Table 1).

(d) sharing knowledge and experience – inner benchmarking (in significant design organizations), which can select partners according to the specific criteria and, thereafter, study, evaluate and apply the knowledge and experience of these partners.

Thus, the application of quality management tools improves the level of quality control of the project development process in any area not only during entry and exit actions but also within the framework of this process itself, i.e. executing monitoring and measurement [1]. Such designed application methods results in high effectiveness during significant decrease of time-consuming monitoring and corrective actions.

**Fig. 2. Pareto diagram to Number of Detected Discrepancy**

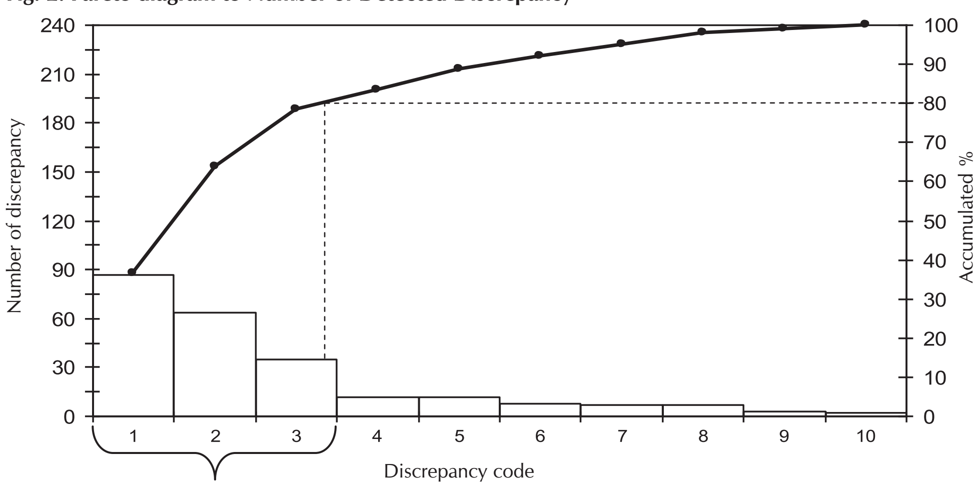


**Table 1. Application of Quality Management Tools**

| Cycle stage | Process | Tool |
|---|---|---|
| P (plan) – planning | Process planning | Arrow diagram (Gant diagram) |
| | | Just-in-time (compliance with a deadline) |
| | Distribution of responsibilities | Matrix diagram |
| | Engaging highly-qualified employ-ees | Characteristic indicators of em-ployees |
| | | Employee rating (flow chart) |
| | Determination of factors, influencing the process quality | Matrix diagram |
| | | Communication diagram |
| | Determination of potential discrep-ancy, designing preventive actions | Decision-making program (plan) |
| | Analysis of reasons and consequences of potential discrepancy and failures | FMEA-analysis |
| | Recording requirements of specific or potential consumers | QFD («House of Quality», Quality Function Deployment) |
| D (do) – implementation | Determining execution sequence | Data-flow diagram (Flow diagram ) |
| C (check) – control | Data concentration of discrepancies | Log sheets |
| | Identifying most substantial dis-crepancies | Pareto diagram |
| | Determining the causes of emerging discrepancies | Cause-and-effect diagram (Ishi-kawa\ fishbone diagram) |
| A (act) – action | Deployment of discrepancies | Affinity diagram |
| | Analysis of cause-and-effect failures | FMEA-analysis |
| | Recording and analysis of consumer satisfaction | QFD («House of Quality», Quality Function Deployment) |
| P’ | Determining improvement targets | Tree diagram (Target-tree ) |
| | Sharing knowledge and experience | Benchmarking |
| | | Priority matrix |
| | Refer to “P” | |

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# Sustainable Technological Facilities in ESPC Educational Institutions as a Factor of Efficiency and Quality Improvement of Engineering Education

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**The article presents and proves scientific concept of sustainable technological facilities development in integrated scientific-educational institutions aimed at improving quality and efficiency of engineering education.**

***Key words:*** *educational system, rational technological resource base, system multilevel of monitoring, synergetic, educational service.*

## Introduction

The foundation of high-quality engineering education is a profound academic training based on latest scientific and technical achievements. Implementation of this principle requires creation of training technological facilities. Technological facilities are an important constituent of scientific and educational potential of universities. It ensures both the possibility to conduct research and training work and its efficiency. These facilities can be definitely considered as the governing factor of quality assurance of the whole technical higher education [1].

The distinguishing feature of a contemporary development stage of higher professional education (HPE) is the increasing importance of practical training and, as a consequence, creation of a fundamentally new education-science-production complex (ESPC). Thus, universities purchase new equipment that would provide a required level of specialists' training, which increase cost value and reduces profit of educational service. This fact is also conditioned by constant cost increase of equipment.

There are two ways to reduce expenditures connected with equipment acquisition and maintenance and increase in education efficiency.

The first approach is associated with crucial changes in the university structure. Recently a steady trend has been observed in Russian higher education system- new forms of science – production integration are being developed: corporate universities, technoparks, incubators focused on new technologies, new technology centers, innovative-industrial complexes etc.

Sure achievement of "integration policy" is a synergetic effect of mutual support reflected in principally new intellectual products made in the frame of every subsystem of the whole chain "education – science – production" [2].

The second approach is connected with the system of university finance and economics management. To continue extending business efficiency of universities it is necessary to intensify factors causing

ENGINEERING EDUCATION 13'2013

changes in IT, management and financial aspects of universities' business functions. In other words, university should develop its economic mechanism relying on economics and IT [3, 4].

However, both approaches are focused only on cutting the costs associated with buying equipment and its maintenance. Still they do not reflect the dependence of students' competence development quality on the use of training, scientific and industrial equipment.

Nowadays the process of equipment renovation in universities is of stochastic nature and is not supported by objective factors or scientifically based. Besides, there is not an index system to reflect the dependence of facilities expenditures on the quality of competences development at every training stage. Such system would solve the problem of inefficient facilities expenditures. Moreover, it would contribute to sound financial management of educational service and development of sustainable technological facilities of universities.

It makes most sense to develop the above mentioned index system for monitoring researches using the Quality Management System (QMS) of a university based on international quality standards ISO 9001 [5].

## Educational service and learning outcomes as indices of monitoring technological facilities condition

In process of monitoring an index system of educational services and learning outcomes based on university's QMS is developed. The indices comprise all the stages of training: the first level (educational), the second one (scientific) and the third level (production), which makes the monitoring a systems multilevel one.

Structural components of educational service aiming at leaning outcomes achievement are:

- Educational program quality (structure and content);
- Curriculum and teaching process quality;
- Faculty quality;
- Teaching methods quality;
- Quality of resources:
  - Facilities (classes and labs, equipment, expendable material);
  - Informational and methodological support (textbooks, training aids, problem books, models, simulators etc.
- Scientific research quality, innovative technologies in the frame of ESPC, collaboration with research institutes, industrial enterprises and other universities.

The following things were developed to evaluate the quality of learning outcomes in the frame of university's QMS:

- Evaluation schemes;
- QMS that guarantees systematic achievements of learning outcomes [6].

At the same time the objectives of the researches are the following:

- to structure competencies distinguishing components of professional activity;
- to apply appropriate pedagogical technologies to develop the above mentioned components of competencies;
- to develop learning outcomes evaluation system to control quality of the developed competence components;

At the preparatory stage of the monitoring special attention should be paid to the status of educational programs and their international accreditation. Russia joined Bologna process, which makes it necessary for the national educational system to meet the international standard requirements. Therefore, it is useful to have the programs accredited in "Framework Standards for the accreditation of engineering study programs" of EUR-ACE [7]. Accreditation center of AEER has the right to award EUR-ACE quality label to the accredited programs [8].

According to the quality management principles, reflected in ISO 9000:2000 [9], monitoring researches cover all the subsystems of university education and allow specialists:

- to obtain objective cost estimate of educational service at each training stage (university expenditures);
- to evaluate the number of students having excellent and good knowledge, skills and competencies developed during the training process that involves training, scientific and pro-

duction facilities; then knowing the university's expenditures to determine the university's income;

- to analyze the components of educational service quality of each stage and determine the expenditure values for facilities improvement for each training stage.

Monitoring researches make it possible to evaluate each component of educational service, i.e. to expose weak and strong points of a training process. That is why a sound use of university's income for creating technological facilities based on the monitoring researches will definitely contribute to the increase of training process efficiency [10].

Thus, the monitoring researches allow developing a system of indices showing the connection between the investments in technological facilities for training process and the quality of students' competence development.

## Synergetic effect

The educational system has some characteristics that make it possible to study it in terms of synergetics methodology as an open self-organizing non-linear system. This system can reach unstable state and have energy, information and substance sources and run offs [11, 12].

According to the self-organization theory one of the necessary conditions for a system to achieve a new qualitative state is to distinguish the leading component of the social development (in most cases it is technical or management innovation) and ensure its self-development.

It is very important for self-organization of the educational system that the educational services embrace all the subsystems of the university educational system [13]. Thus, the educational service of competence acquisition is offered at all stages of the educational process: in classes, training labs and industrial internships. This process involves faculty members, textbooks, training aids, training process management, program development and facilities.

The key principle of quality management is a process approach, that implies that a desired goal is achieved more effectively if all the corresponding activities and resources are regarded and managed as a process.

"Any activity in an organization should be regarded as a process, consequently, it should have well-defined inputs and outputs, resources, actions and interactions of all corresponding process components" [9].

While conducting monitoring it is suggested to consider the educational process at three levels. The input indices are the educational service of the preceding level and the output indices are the learning outcomes of the present level. The interaction between the educational levels is ensured by the educational program of a definite specialty.

The monitoring should be conducted from the prospective of synergetic approach. "We regard synergetic approach as a scientific knowledge method based on systems analysis of self-developing evolutionary system characterized by periods of prosperity and decline. It is possible to distinguish dynamic attractors there. The attractors are processes of information self-organization and generation of new rank parameters and bifurcation point. Fluctuations, i.e. "stochastic processes" are the leading factors of bifurcation" [14].

Monitoring of each level will allow introducing the management element in the training process. The management of every stage of the training process will be focused on the management of the whole educational process. Topologically correct organization of the subsystems leads to the maximum development of the system, which results in synergetic effect. "The whole united area becomes under the influence of new more intensive development process. The whole unit develops faster than its constituent parts. It is more useful and efficient to grow together, as it saves material, spiritual and other expenses" [12]. We suppose that the attractor is a qualitative new system state characterized by increasing quality of educational process.

Self-organization of a pedagogical subsystem will contribute to the dynamic equilibrium of economics, its sustainable development path determined by efficient use of university's resources.

However, while self-organization is an objective reason for activation of system development, organization is the way to regulate or to arrange initiatives of this or that forms. Self-organization can lead to negative results and needs to be corrected and supported by operating parameters.

That is why the aim of management is to create conditions for coordinated subsystems interaction that ensures functioning of the whole system, its safety and development and to ensure communicative links between the subsystems of an educational complex [15].

Thus, organizational innovation in the form of a systems pedagogical and economical multi-level monitoring aims to establish an index system reflecting the connections between technological facilities expenditure and the quality of learning outcomes and can lead the system to self-organization – a new qualitative state characterized as "sustainable technological facilities".

The monitoring researches can serve as a base for economic and mathematical model of sustainable technological facilities.

IT implementation will allow developing automated control system of educational process, which will increase efficiency of university educational system.

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# Advanced Development of Engineering Education in Russia

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**The article deals with modern conditions of the education in Russia including engineering education and its development perspectives. The design of the best in the World Russian education completely free at all levels with restoration of a Teacher's status has been suggested for improving the unity and advanced development of Russia. The finite purpose is to increase the living quality of Russian people by modernization of the country.**

***Key words:*** *problems of training, staff training, sistems training, skills, higher educational instition, engineer.*

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Development of engineering education is one of the main bases of modernization in our country focused on unity and progressive development of Russia.

In due course the President of Russia D.A. Medvedev called modernization «an issue of survival of our country in the modern World». He pointed out: *"We need to modernize our production, our industry, we should introduce new technology, use new materials, involve specialists, teach our engineers better, search for foreign specialists who would assist in modernization". (Newspaper «Izvestia», 2010, №169, p.3 of 13, September)*

The necessity of modernization in our country is conditioned by many objective causes: run-out of Soviet economy reconstruction, necessity of renewal and creation of new efficient economy for advanced development of the country, transition to the civilized way of development without criminality, corruption, based on single Laws for every citizen, further development of democratization, formation of leading World country from Russia etc. In general the finite goal of the country's modernization is to increase in life quality of every Russian [1-3].

By modernization of the country Russians mean different points: equality of all before law (41%), tough corruption fighting (38%), social justice (31%), efficient innovative economy (24%), force and mighty of the country (21%), revival of the Russian traditions (14%), new opportunities for commercial activity and competition (12%) and democracy enhancement (7%). In general, they are all right since modernization involves renewal of all spheres of society. Therefore, the country's modernization is vital.

Modernization is characterized by the level of education and technological level.

According to the level of education before 1991, in terms of UNO data, Soviet education made the top three educations in the world, but after adoption of English-American two-level education system with USE our country took the 66-th place in the world in 2011 – dropped approximately 30 times and continues to decrease.

In terms of engineering level according to the data of UNO, our country took the 62-nd place in the world in 2011 (between Costa-Rica and Pakistan) [1].

In the given period progressive development of our country is performed in two types of modernization: following and advanced [4][1], properties of which are the following:

**1. Following modernization – using contemporary foreign technologies characterized by yesterday level of development passed off as "new".**

- liquidation of great Soviet education, completely free at all levels and introduction instead of it expensive English-American system of education with its USE crossword solution system and degrees: Master, Bachelor, and Specialist;
- application of international standards for the following economy;
- low development of domestic technologies with «enhanced» standard indicators;
- introduction of market-kickback economy with money paradigm (money at all costs, getting money from everything);
- absence of progressive tax system focused on the efficient development of our country;
- outpouring of money into foreign «saving fund» and offshore that will never return to Russia but remain abroad through the bank bankruptcy;
- insufficient development level of engineering education and reluctance of engineers to be hired by employers who need neither education nor science, but only money.

As a result they consider that one need not develop new technologies, but it is cheaper to buy them abroad with kickback. Such a following modernization presents only temporary «patches» on the engineering development of our country. Therefore, Russia needs the advanced modernization.

**2. Advanced modernization means creation of newest high technologies advancing the contemporary level of country's development and directed at integrity and progressive development of Russia:**

- creation of the world best education in Russia based on the domestic and foreign experience, fully free at all levels;
- rebirth of the distinguished title of a Russian engineer – a base for advanced modernization, combining efficiently engineering and humanitarian disciplines with awareness and intellect higher than foreign masters, bachelors and engineers;
- development of Russian standards, indicators of which exceed the international standards necessary for advanced modernization;
- introduction of efficient plan-market economy with progressive tax system and replacement of money paradigm into intelligent paradigm – all for unity and progressive development of Russia;
- investment of finance not aboard, but only to the Central Bank of Russia for progressive development of the country.

As a result it is necessary to create a harmonic unity of education-science-engineering:

- strengthening of unity of the Russian Science Academy subordinate directly only to the

[1] *Note: The word «industrialization» in the article [5] is likely to be replaced by the word "modernization" in the given work, as it suggests renewal of the whole country in its progressive development. To modernize means to make modern, change in terms of contemporary requirements absolutely everything: technologies, equipment, agriculture, life-style, thinking etc.*

President of the country and not accessible for different official clerks who are very far from education and science with money paradigm;
- restoration of branch science involved in introduction of academic science and performing the advanced modernization at the patent level;
- moral and finance stimulation of development and introduction of latest technologies with high degree of customer's use.

It is just advanced modernization of the country that would provide its strength and progressive development.

As a result one needs to assist the President of Russia in increasing the life quality of Russians, but not opposing and consolidating stupidly wasting time and nerves absolutely uselessly.

Modernization begins with education including increase in the level of engineering education that means increase in the level of knowledge and intelligence [3]. Therefore, it means formation of harmonic combination of engineering and humanitarian knowledge at all levels of education.

Engineering education in Russia is more than 300 year old. At first Peter I established "The School of Mathematical and Navigation Sciences" supported by the state and focused on development of engineering education. Then in 1773 Ekaterina II founded the first in Russia higher engineering university in Saint-Petersburg (Mining Institute). Hereafter two universities were opened: Moscow State Technological University named after N.E. Bauman, the leading one in the Russian education and Tomsk Technological Institute – the first in the Asian part of Russia engineering institution, now National Research Tomsk Polytechnic University which is 110 year old now [5]. Engineering education in Russia was successfully developing especially in the Soviet period contributing greatly to the economy of our country.

Let us recall the history of our country. Thus, in 1917-18 when there was complete ruin in the country, the private property was appropriated in the economy, there was lack of food and clothes, and there was high illiteracy in the country, V.I. Lenin despite his numerous disadvantages, put forward two great decisive ideas:

1. "Learn, learn, and again learn". That is it is necessary to start the progressive development of Russia with increase in education level – a sum of knowledge and intelligence. Education for everybody was introduced, schools, institutes, universities were built. Everyone understood that if the education of people was not extending, no progressive development of the country could be achieved.

Let us imagine that instead of V.I. Lenin some modern magnate would have come to power (people call them pushers, in old style – representatives of bourgeoisie) and have said to give up learning, and just earn money in any way. It is difficult to imagine what colony our country would have become.

2. The main force that had to develop industry and agriculture progressively was energy industry, namely, electromagnetic energy. Therefore, the plan GOELRO was adopted – a base of Russian development. Actually, only electrification of the entire country made Russia one of the leading countries in the world.

These two fundamental ideas – extension of education and development of energy industry were primary, urgent, and essential even in our time for successful progressive development of Russia. However, they are in sharp contradiction with the American concept of Russia's existence.

The developed «National Doctrine of Engineering Education of Russia» is certain to be the most important positive step on its way of progressive development, but it is characterized by the lack of juridical bases.

Hence, new "Law of Russian Education" is crucial nowadays that reflects a sufficient increase in the level of engineering education in our country [6].

"Law of Russian Education" is expected to include the following statements.

1. It is necessary to rebirth the social status and prestige of Teachers, and the word Teacher should be written with capital letter with all that it implies. For this purpose, for example, one must increase sharply 2-5 times Teachers' salary, particularly, in rural area it should be more than in cities.

In our country Teachers are to be the richest people, because they give their lives to others; live for the sake of others, but not for the sake of accounts in offshore.

2. Education in Russia should be continuous and constant: from the lower level – infant school, smoothly transmitting to kindergarten, then – to school with division into work, vocational (colleges) and higher (universities). Further education for those who wish is post-graduate course, doctorate course, and academic course – in fact, limitless. Everybody has to learn including a Teacher at the modern refresher upgrade courses with involvement of Russian Academy of Sciences (RAS).

3. Continuous education should be a harmonic unity of learning and work. It is ultimately necessary to learn and work continuously in different combinations and volumes depending on the age of a person. Figuratively speaking, a person has to learn and work from the first to the last breath.

4. Study presents an increase in awareness of newest natural-engineering and humanitarian sciences in their harmonic unity. It is just unity of natural-engineering and humanitarian knowledge provides increase in human intellect – a base for progressive development of our country. Engineering knowledge is to be combined with the objective outlook – humanitarian knowledge.

Hence, engineering and humanitarian knowledge is the one whole.

5. Complete contemporary infrastructure of the entire education: computerization with use of artificial intellect software, internet, up-to-date informatics, newest basic and optional manuals in engineering and humanitarian sciences, construction of modern infant schools, kindergartens, schools, colleges, universities and other educational institutions.

Russian education is based on information technologies.

6. Russian education at all levels from the bottom to the top is to be completely free, financed 50% from the state budget and 50% - from the local one, since fee-based education prevents from progressive development of our country and contradicts the RF constitution (Article 43).

In the newspaper «Nauka Urala» (Science of Ural) (2010, №16, p.3) it is pointed out: "The growth of fee-based education share leads to further differentiation of society and again – to retardation of knowledge and industry". Hence, one needs liquidation of fee-based education.

7. University entrance is to be absolutely free – everyone who wishes can enter a university freely. The only criterion for one's entrance is his/her level of knowledge. Admission committee defines only an entrant's level of knowledge without taking into account his/her awards and achievements.

All entrant's awards and categories: medals, Olympiad prizes, special purpose entrants, magnate's children etc. are of no significance for admission committee – the only important fundamental criterion is an entrant's knowledge level. Entrant's achievements serve for him/her as a means for increasing the level of knowledge that is defined by the admission committee.

Details: any entrant is to apply the documents for the university human resource department and is given an application certificate. He/she passes exams in admission committee with this certificate. Exam papers on each discipline are not kept away, but are put on the internet approximately a year before exam date (about 100 exam papers on each subject with systematic presentation of knowledge for everyone to have access and prepare on his/her own. Entrant takes a ball from a rotating drum at admission committee, opens it and announces the paper number, takes a notebook, opens exam paper and prepares for exam. Admission committee has no problems with the exam papers. Content of papers is changed once a year after finishing student's acceptance. At the university entrance exams entrants should not have mobile phones. If admission committee finds out some cheating or an entrant goes out from the room under some pretext, his exam paper is changed into a new one – so, one need not spy entrants. In this case it is absolutely forbidden to blitz the entrants from exam, but change their papers that will allow committee to achieve the main goal – to assess every entrant's knowledge objectively.

Assessment of knowledge level at all stages is made using 5-point scale, which reflects it in the most objective way. 10-point, 100-point scales etc. of knowledge assessment are not reasonable, as it is the same as to measure the distance from the Earth to the Moon in millimeters.

Such a free entrance system in universities is the most efficient one, not requiring capital inputs, simple, entirely excluding corruption, and, as a result, permitting for students' acceptance to university only with high knowledge level which is necessary for universities.

One must abandon compulsory university graduate's assignment, particularly special-purpose students. During the first year study students are to find several future positions by themselves. It would permit them to learn purposefully, besides common core universities are to stimulate student's attendance extra lectures, courses, practical classes in their university and other. Because in future education will be completely free, that will permit for intensification of engineering education additionally.

8. Engineering universities of our country would train, as it was before, highly qualified Russian engineers with harmonic unity of engineering and humanitarian knowledge, since only Russian engineers are a base for modernization of our country's economy.

The number of engineers, technicians, and workers is determined not by employers, but modernization demands. It is conditioned by the fact that in our country only forced modernization with the help of government is possible by means of introducing progressive tax system, but voluntary modernization is virtually unlikely.

Country's modernization is necessary to start with modernization of conscious (mind) and only after that one can turn to modernization of economy.

It is impossible to cover all numerous issues of "The Law of Russian Education". Therefore, the order of its design and adoption is given below.

1. First, special software «The Law of Russian Education» is to be developed that includes all positive points achieved in the education of our country and abroad with their objective analysis and necessary calculations.

2. Based on the software the project «The Law of Russian Education» is to be designed and written in a clear, simple language understandable to everyone.

3. The project of the law is brought up for discussion to introduce corrections and additions. Only after this the first draft of the law is developed that is given to the President and government for discussion, follow-on revision, adoption in its finite version.

4. Supervisor and designer of "The Law of Russian Education" is the Russian Education Committee with participation of the Russian Academy of Sciences.

Such an order of design and adoption of the law is grounded and efficient.

It is necessary to warn that development and adoption of «The Law of Russian Education» will stir up the opposition and get a negative feedback on the part of strongly formed joint: clerks, KGB, magnates, criminals, and an army of "buy-sell" dealers. Since the given law contradicts the American concept of Russia's development, President, government, and discussion of the law by people are our white hope.

It should be repeated that "the Euro-repair in education" with its two-level system and USE are sure to be abandoned, the loss to be calculated including legislative one and one needs to transfer to the Russian education – the highest and best in the world. Such an education is a base for successful development of Russia.

The finite goal of the Russian engineering education is formation of a Human being with a capital letter, progressively developing and living in harmony with the Nature, society, and himself. Russian engineers are a ground for modernization of our country and its progressive development.

## Conclusions

1. It is necessary to increase the level of education in Russia and occupy again one of the leading places in the world in this sphere.
2. To increase the education level one must stop «the euro-repair in education» and start the development and adoption of "The Law of Russian Education" including all positive experience both in the country and abroad.
3. The order of development and adoption of the Law is the following: first the Law software is developed, then the Law project is designed, brought up for discussion, reviewed and given to the President and government.
4. "The Law of Russian Education" is developed by the Russian Education Committee with participation of the Russian Academy of Sciences.
5. "The Law of Russian Education" is necessary and urgent for successful progressive development of Russia. Such a Law will be just, objective, and fully correspond to the basic statements of materialistic dialectics, i.e. scientifically grounded [1].

Thus, progressive development of engineering education in Russia is based on training of highly educated engineers with harmonic unity of engineering and humanitarian sciences, high level of knowledge and intellect. The sense of engineers consists in learning unknown and creation of uncreated on the basis of intellect paradigm – all is for strengthening the unity and progressive development of Russia.

* * *

Ask any Russian: "Would you like your children to get free education at all levels, the best in the world Russian education?" 100% answer "YES" is guaranteed – Then "Law of Russian Education" should be adopted. This is a base of the truth.

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# Improving Educational Activity at Belgorod State National Research University Based on the Concept of Practice-Oriented Learning

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**The efficiency of university – employer cooperation could be evaluated by such indicators as the degree of compliance of graduates training quality with the employers' requirements, demand for graduates in the labour market and the efficient use of human resources. Creating conditions for successful implementation of practice-oriented learning in the system of vocational education, will enhance the competitiveness of graduates in the labour market and strengthen position of higher education institution in system of vocational education.**

***Key words:*** *university – employer cooperation, concept of practice-oriented learning, Global initiative CDIO, applied baccalaureate.*

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Current socio-economic development of the Russian Federation is characterized by the emergence of the labor force. Their efficient use is a compulsory condition for sustainable economic growth and well-being improvement. Therefore, this issue requires to be studied in a comprehensive way with evidence-based approach.

It is not enough for higher education institution just to prepare the graduate in the field of training, it is necessary to continuously monitor the labour market needs and focus on the demands of a particular employer.

Bring educational programs to real life, to link theory with practice - these are one of the main challenges that university faces today.

It is necessary to form a constant interaction between university and company where the employer acts as a customer from the labor market, defines learning outcomes as a set of graduates' competencies.

The efficiency of university – employer cooperation could be evaluated by such indicators as the degree of compliance of graduates training quality with the employers' requirements, demand for graduates in the labour market and the efficient use of human resources.

Since September a pilot project of practice-oriented training based on the CDIO global initiative has been run at Belgorod State National Research University (BelSU).

CDIO global initiative is considered as one of the best international practices in convergent training of highly qualified personnel.

In accordance with the CDIO concept graduates should be prepared for the integrated activities throughout the product or service life cycle "Conceive – Design – Implement – Operate)" [1].

For the time being, 91 higher education institutions from 30 countries of the world have joined the project (North America and Latin America, Europe, Asia, Australia and New Zealand, South

Africa), including from Russia (Skolkovo Institute of Science and Technology (2011), Tomsk Polytechnic University (2011), Astrakhan State University (2012)), etc. [3].

BelSU is the first university in the region, which follows the CDIO concept in its activities, with the main focus on teaching practice. This principle is realized in the creation of training programs, their logistical support, recruitment and professional development of teachers. Although originally CDIO project was developed as a methodological framework for software engineering education, today it has become apparent that the CDIO standards ideology and approach apply to the training of specialists in every field.

The purpose of the CDIO initiative is to train students able to manage the processes of creation, operation and sustainable development of new products and systems. Graduates should apply innovative thinking skills in all tasks they have to deal with [2].

Practice-oriented training is largely aimed at independent team-work activities of students under the guidance of the teacher. Students have to complete practical tasks aimed at solving a particular problem.

Implementing CDIO Initiative requires the following steps to be done:

- Bridging the gap between universities and industry;
- Overcoming dissociation of disciplines and departments;
- Gaining real work experience within the training process at university;
- Acquisition of today's professional and personal competencies;
- Integration with the world leading universities;
- Training business and entrepreneurial skills and innovative thinking

In 2013 the pilot project in ctice-oriented 2014 academic year the following institutes and faculties of BelSU joined the CDIO pilot project implementation: Institute of Management, Faculty of Information Technology and Applied Mathematics, Biology and Chemistry Faculty, Physics and Engineering Faculty and the Faculty of Mining and Nature Management

In framework of practice-oriented training several units of BelSU cooperate with companies and enterprises in the region.

For example, Faculty of Information Technology and Applied Mathematics together with Rostelecom designed an educational program to train specialists in the field of telecommunication technologies to meet the requirements of regional employers.

Department of information technology systems and technologies was founded on the basis of CJSC "Spetsradio" with technological development platform for design and production of electronic equipment.

In 2013 academic year Cisco network company started partnership with the Faculty of Information Technology and Applied Mathematics, which will deal with the implementation of joint educational programs for undergraduate and international specialists in networking for businesses in our region. At the Academy of the company professional retraining in this field will be organized.

To promote research and industry as well as to improve the quality of training at BelSU it was decided to establish a basic interdisciplinary department "Medical technology systems" the basis of CJSC "VladMiVa".

Since 2010 CJSC "VladMiVa" in collaboration with researchers from BelSU has started to develop new prospective research field - biocompatible materials for implantology, dental surgery and maxillofacial surgery.

In May 2012, the plant "Premiksov №1" together with BelSU Faculty of Biology launched a pilot experimental plant for the production of lysine. In fact, this is a prototype of the future enterprise in miniature. This plant represents a scientific laboratory for training future biotechnologists and training highly qualified specialists for microbiological industry.

Since 2011, the BelSU Institute of Management together with the administration of Rakitjansky Belgorod region has been working on the project "School of municipal employees".

"School of municipal employees" is focused on creating the conditions for training and professional development of municipal employees by solving real practical problems of municipal administration.

Together with the Belgorod Department of Education our university runs the project "BelSU School". The project aims at developing efficient tools and mechanism for the selection and training at the high quality level school graduates willing to apply BelSU educational programs in the field of mathematics and natural sciences. This helps to make the conditions for the creative development of students, providing high quality training and attracting talented young people to BelSU, as well as the conditions for training future teachers.

Today educational programs of technical secondary schools and colleges, aimed mainly at the development of practical skills, cannot ensure required high level of training. At the same time, university graduates who have acquired good academic knowledge base, often lack practical experience in the real industry conditions.

Therefore, it was necessary to design a practice-oriented applied Bachelor Program on the basis of higher education institution to improve a new qualitative level of education.

The basis of this level of educational programs of secondary vocational education focused on the acquisition of practical skills in the workplace, combined with higher education programs focused on getting fundamental theoretical training.

The volume of the practical part of the program, including laboratory and practical training, educational and industrial practice, is not less than half of the total time available for training.

In other words, the main objective of applied baccalaureate – prepare professionals with higher education degree diploma. Young people get the full set of knowledge and skills required to start working immediately, without additional training needed.

In this case it does not matter that after graduating from applied bachelor program student could not continue further studies – if graduates wish they can apply for Master Degree programs afterwards.

In 2013 Belgorod State National Research University offered first practice-oriented programs of applied baccalaureate: 080500.62 Business Informatics; 034700.62 Documentation and Archive Studies.

From 2014 some more programs of applied baccalaureate could be introduced at the university in the following areas: 230400.62 Information Systems and Technology; 210700.62 Information and Communication Technologies and Communication Systems; 050100.62 Pedagogical Education; 230700.62 Applied Informatics, 050700.62 Special (Defectological) Education; 260800.62 Production Technology and Organization of Public Catering

The aim of introducing practice-oriented learning is to improve the research and educational activities of the university, aimed at training competitive, in-demand able to solve real specific problems.

The list of indicators describing the degree practice-oriented learning implementation should include:

1. Number of practice-oriented educational programs realized at HEI.
2. Particular forms of professional student's activities enabling them to solve real problems in practice.
3. Cooperation agreements between the university and industry enterprises and regional market.
4. Number of research, innovation and promotional structures, including industrial parks, business incubators, etc.
5. Total amount of R&D projects realized on the request of enterprises (organizations) with the involvement of students.
6. Total amount of research funding on targeted programs and grants with students involvement.

7. Amount of funding for initiative innovative projects in the educational, scientific fields involving students.
8. Patents obtained on the research developments of the university with students' participation.
9. Share of courseworks, projects and final works commissioned by the enterprise (organization).
10. Number of students enrolled for practice-oriented programs of targeted training supported by special contract with enterprises (organizations).
11. Percentage of students employed by target applications from enterprises (organizations).
12. Share of students and graduates involved in the creation of start-ups or started their own business.

To achieve the above mentioned objectives it is important to complete the following tasks:

- Expand the range of training courses and professions, practice-oriented educational programs in accordance with the needs of employers.
- Strengthen the interaction between the structural units of the university and employers' organizations to conduct joint research and R&D projects, special targeted contract training and other activities.
- Improve the quality of graduate training in accordance with the future requirements of the labor market by engaging employers in the process of vocational training, as well as for current, interim and final control tests, etc.
- Engage employers to career-oriented activities among school students, and among students at the university.
- Develop mechanisms to encourage employees and students who have attained good results in implementing the concept of practice-oriented learning.
- Create information environment using internet technologies for collaboration with employers, students, faculty and staff of BelSU within practice-oriented training and promote employment of graduates.
- Interaction with employers to improve the system of social support of students and young professionals, the formation of an infrastructure to support students' entrepreneurship.

To reach these goals Belgorod State National Research University developed algorithm presented in the form of a typical road map facilitating interaction of university departments with enterprises (organizations) - employers when implementing the concept of practice-oriented learning.

These measures will enhance the effectiveness of the system of vocational education and create conditions for successful implementation of practice-oriented learning, which ultimately will increase the competitiveness of graduates in the labor market and strengthen the position of the university in the vocational education system.



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УДК 378

# Engineering Education 2.0: the Eindhoven Case

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***D.-J. W. M. Mulders***

**In response to complaints from industry in the 1990-s that engineering graduates had been educated too theoretically, Eindhoven University of Technology first developed the concept of Design-Based Learning, which was successfully implemented from the year 2000. More recent developments, both globally and locally, necessitated a more fundamental reform of all TU/e education. In 2012 a totally new design of BSc education was put in place, with encouraging results thus far. More reforms, including graduate studies, are underway.**

***Key words:*** *engineering education, professional skills, educational reform, curriculum design.*

**D.-J. W. M. Mulders**

## Engineering Education 1.0: The classical approach

Following decades in the 20th century during which industry seemed to be perfectly happy with the engineers graduating from university, during the 1990s the first complaints from the corporate world started reaching the universities of technology in the Netherlands. University-educated engineers were considered to be theoretically strong within their own academic discipline, but lacking in practical skills, in solving problems and in an integrated, multidisciplinary approach. Hence, additional in-company training was required before university graduates in engineering would become truly useful with an industrial setting.

If we look back at engineering education as it was in the 20th century, a number of characteristics stand out:

- All education was based on the academic discipline in question, e.g. Mechanical Engineering, Electrical Engineering, Applied Physics.
- While students did have occasional practical labs, they spent most of their time sitting in lecture halls, taking in what their professors were telling them.
- Individual subjects were typically taught separately by individual professors. Integration of subject matter was left to students.
- In general, students had a fairly passive role in their education. They were expected to take notes during lectures, study literature and display mastery of subject matter during examinations with an emphasis on reproduction of knowledge.
- Theory and practice were strictly separated. Practice consisted of isolated lab work and perhaps an internship, and that was that.
- Studying engineering was a strictly individual affair. Co-operation in groups was rarely, if ever, required.

In view of these characteristics – let's label them Engineering Education 1.0 – the complaints from industry could hardly have come as a surprise. What engineering students were confronted with was essentially a large pile of individual theoretical subjects which they were required to reproduce, without much attention being paid to labour market requirements.

## Engineering Education 1.1: Design-Based Learning

At Eindhoven University of Technology (TU/e), by the end of the 1990s it became clear that something needed to be done. In order to deal with the criticisms from industry, the university adopted a new concept called Design-Based Learning (DBL). While classical elements of engineering education were retained, engineering students in the new millennium would now spend roughly one third of their time in DBL-type education.

Now what would DBL entail? Nationally renowned professor of education Wynand Wijnen was hired to work on this issue. What he came up with, was not a single teaching method, but a number of characteristics a certain curriculum part would need to have in order to be called DBL.

The six DBL characteristics (Wijnen, 1999; Wijnen et al., 2000) include:

1. Professionalisation: design-based learning should be profession-based rather than driven by the structure of the academic discipline. There should be more cohesion with the field and learning should be more practical and application-oriented than traditional engineering education.

2. Activation of students: students would be required to act more rather than sit back and wait what's in store for them. They would have to show more initiative rather than just follow prescribed rules, and spend more time in small groups rather than large anonymous crowds in which non-participation isn't easily noticed. Hence learning becomes more demand-driven rather than the traditional supply-driven approach.

3. Co-operation between students: more working in teams rather than individually, in less homogeneous groups in which students are more mutually supportive and complementary, rather than everyone for him- or herself according to a uniform mould.

4. Creativity: more original and productive work, rather than reproduction of standard knowledge; more emphasis on developing new solutions than on application of already known solutions; more divergence in approaches rather than convergence.

5. Integration: theory and practice combined rather than separated; more emphasis on relations between subjects rather than on separate subjects; more theme-based learning rather than by individual subject; more team-teaching instead of individual teaching.

6. Multidisciplinarity: surpassing individual disciplines, more thematic rather than per individual course; encompassing more engineering disciplines rather than within a single discipline; more holistic rather than atomistic.

Please note the function of the phenomenon of design in all this: DBL does NOT mean that students are taught a course in which they learn to design. It means that designing is a process which lends itself very well for application of the six characteristics mentioned above; hence students learn in a design-based way through the process of designing. In short: design is a means here, not an end.

In the year 2000, implementation of DBL within the Eindhoven engineering programmes started. It soon became apparent that there was a wide variety in the ways DBL was conceived and implemented by the individual disciplines, departments and programmes within TU/e. One size did not fit all. For instance, in the Industrial and Applied Mathematics programme, settings in which pairs of students work on modeling assignments became the preferred way of implementing DBL, whereas disciplines such as Mechanical Engineering had students work in small groups of 6-8 students on projects derived from practice. This variety was deemed a good thing; the intention never was to impose a single pedagogical model in a top-down way.

While the implementation of DBL started hesitantly and a fair amount of internal resistance to change had to be overcome, after a few years DBL-type teaching and learning methods could be found throughout the university (as noted before: always in combination with more classically taught curriculum parts). Engineering Education 1.1 was a fact.

## Evaluation of DBL

In 2007, discussions were held with all BSc programme directors in order to informally evaluate the results of DBL until then (Peters, 2007). The programme directors were unanimous that the characteristics professionalization, activation, co-operation and creativity had been successfully incorporated into TU/e education through DBL. The integration and multidisciplinarity aspects turned out to be more difficult to implement. Whereas initially assessment of group work at the individual level was found to be difficult, over time different ways to tackle this issue had been developed, often by including peer review among students in the overall assessment. This was also used to deal with free-riding behaviour within groups of students.

DBL was found to stimulate students to work hard and spend much time on learning, sometimes at the expense of more classically taught subjects. In general, students were satisfied or even enthusiastic about DBL.

Programme directors unanimously agreed that DBL was to be continued and developed further.

A more recent analysis, using the ACQA (Academic Competences and Quality Assurance) framework developed at TU/e (Meijers et al., 2005), has demonstrated that DBL courses scored significantly higher on all DBL aspects except integration than non-DBL courses (Perrenet & Van de Wouw, 2013). Differences between DBL courses were mainly in the area of multidisciplinarity. Additional analyses showed a contrast between DBL and non-DBL courses in the relative weight of different areas of academic competence, with DBL courses emphasizing synthesis, design, co-operation and communication, and non-DBL courses showing more focus on intellectual basic skills, the scientific approach and abstraction, with disciplinary competence always at the forefront.

Thus, a fair balance between various relevant academic competences seems to has been struck through the introduction of DBL.

## New needs and new challenges

Part of the mission of TU/e is to educate new generation of future-proof academic engineers, i.e. engineers who are able to make a significant contribution to society ten, twenty or forty years into the future (Meijers & Den Brok, 2013). Nobody is able to predict with any degree of certainty or accuracy what our society will look like in the future, which is why engineers will have to excel in a number of generic competences, necessary regardless of what the future holds. The American National Academy of Engineers (NAE) developed four scenarios for the future development of the world (NAE, 2004):

1. The Next Scientific Revolution, with technology as a driving force for future change.
2. The Biotechnology Revolution, with the social and societal impact of technological innovation and attitudes in society as key issues.
3. The Natural World scenario, in which forces of nature are determining mankind's future, with a role for engineers to predict and develop methods to handle natural events.
4. Influence of Global Change, in which globalisation and world-wide challenges are key.

Since no one can predict the future and the world will probably facing a mix of these scenarios, a university of technology's job is to educate engineers in such a way that they are able to play a meaningful role in each of the NAE scenarios. This has led TU/e to the conclusion that the engineer of the future does not exist and that different types of engineers should be educated (TU/e, 2011).

While it is true that the future is largely unpredictable, some more robust and predictable developments can also be identified (Meijers & Den Brok, 2013). One such trend is that technology is playing an increasingly important role in people's private lives (mobile phones, Facebook, Twitter etc.) Technology has developed an enormous breadth over the years – a good example is the increasing role of technology in health care.

Another clear trend is internationalization, and partly in conjunction with this, more diversity in types of students.

The landscape is thus changing rapidly when it comes to educating "the engineers of the future". "The rise of smart machines, a globally connected world, superstructured organisations and emerging new technologies will all have their influence on higher education in general and engineering education in particular. Engineers of the future need to be able to make connections with ever expanding frontiers of science and technology and different fields of expertise and use this knowledge and these insights in their work. This holds for aspects like behavioural influence and social cohesion, but also for what we can learn from nature." (TU/e, 2013).

Against this global background, TU/e has been facing some serious challenges of its own in recent years:

- Insufficient student intake to meet the demand for engineers in the corporate world.
- Decreasing market share, with a perspective of unfavourable demographic prospects in the region (lowest birth rates in the country), which could well lead to further decline.
- Low success rates of students who on average take too long to complete their studies (around five years ago, only around 32% of the students who continued their studies after the first year managed to complete the 3-year BSc curriculum within four years).
- A problem found throughout Western Europe was (and still is) – and unlike the situation in the Russian Federation, as far as I know – the low interest among females in studying engineering. While participation of girls was well below 50% in all TU/e engineering programmes, at TU/e especially in Electrical Engineering and in Computer Science no more than 1 or 2% of the student population consisted of girls.

In combination, these factors started to form an existential threat to the university. If nothing would be done, the future student base would become so small that it became questionable whether TU/e would be able to survive in the long run.

In the face of these massive challenges, both global and local, TU/e has chosen to undertake the most fundamental educational innovation in its history, the outlines of which will be described below.

## Towards Engineering Education 2.0: the Eindhoven approach

A dedicated Task Force was established which should develop a fundamental re-design of TU/e's Bachelor programmes, with a view on making them attractive and accessible to a larger group of students, taking into consideration the different types of students that might be interested in studying at TU/e.

Some research on the latter issue had been done in 2007 (YoungWorks, 2007), which had resulted in the so-called "BètaMentality model". This model divided adolescents into four categories:

1. concrete bètas: intrinsically motivated by technology;
2. career bètas: motivated by career perspectives;
3. human oriented generalists: want to contribute to solving problems in society;
4. non-bètas: little to no motivation to study science and/or technology.

Further studies demonstrated at no less than 66% of TU/e students consisted of "concrete bètas", whereas this group only comprises 17% of the total population of students in Dutch university-preparatory education. These findings suggested that large groups of students potentially interested in science and technology were so far not attracted by TU/e.

The TU/e Task Force presented its final report in May 2011 and presented far-reaching recommendations which were followed to a large extent. All TU/e bachelor programmes would in future be offered under the umbrella of a TU/e Bachelor College, headed by a Dean. All programmes would have a common curriculum structure, which is shown in the following figure (unfortunately in Dutch) (Fig. 1).

A Dutch academic Bachelor programme comprises a total of 180 credits (EC). In the new TU/e BSc model:

- 90 credits (shown in light blue) are devoted to a major, chosen by the student
- 45 credits (shown in red) are devoted to electives
- 30 credits (shown in orange) are devoted to institution-wide basic courses
- 15 credits (shown in dark blue) are devoted to "USE", which means User, Society, Enterprise.

The 30 credits that all TU/e Bachelor students should spend in basic courses comprise 6 institution-wide common courses, and thus represent a common body of knowledge of all TU/e BSc graduates. These courses include (Fig. 2):

- Maths
- Applied Natural sciences
- Modeling
- Design
- User, Society & Enterprise
- Professional skills

with a study load of 5 credits each.

**Fig. 1. General curriculum structure**

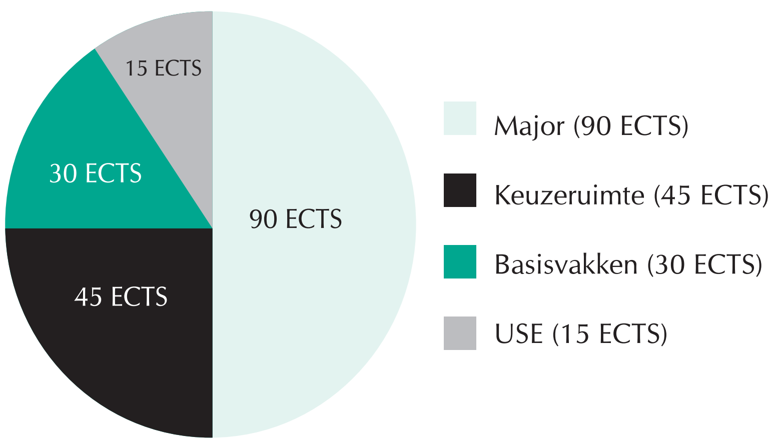

**Fig. 2.**

- Maths
- Applied Natural sciences
- Modeling
- Design
- User, Society & Enterprise
- Professional skills

Professional skills are taught integrated in the curriculum of the major the student has chosen; in our experience learning these works best when related to subject matter and not separately.

The relatively large amount of electives in our new BSc model is related to TU/e's conviction that it needs to educate different types of engineers: while many students, like before, will opt to go in-depth as much as they can (especially the so-called "concrete betas"), other categories of students can combine various interests into a broad package of subject matter if they choose to. This should appeal to both "career betas" and "human oriented generalists". Other measures were taken as well.

- Professors were to perform a new role as well: coaching students in the many choices they would be required to make in the new model.
- Curriculum units should be 5 credits, while in the past they tended to be smaller.
- Intermediate examinations were introduced to provide early feedback to students on their performance.
- No more than three units should be taught simultaneously (in the same term), preventing the competition for the students' attention among too many course units.
- A maximum of 24 hours a week was introduced for in-class activities. In the past, some programmes were overburdened leaving the students virtually no time for independent study.
- Teaching methods should activate students as much as possible.
- Majors were developed in new, mostly interdisciplinary, areas, including Automotive Technology and Psychology & Technology.
- Existing honours programmes were completely restructured into the TU/e Honours Academy, which offers extra challenges to the very best students.

The new curriculum model took effect in September 2012.

## First results

After a little over a year, the first results of the new BSc model are encouraging. The past two years have witnessed a significant increase in student numbers, about 15% per year. The traditional TU/e student intake, the concrete betas, have not been deterred by the new curriculum design, whereas specially "human oriented generalists" have come to TU/e in much larger numbers than before. The start of the TU/e Bachelor College resulted in a 50%

increase in female first-year students. In the new design, students perform better as well: less drop-outs, better study progress. Student evaluations revealed that students found their studies to be interesting and challenging. On average they rated their studies 7.25 on a 10-point scale. Of course, the new design had its flaws as well; especially the design of the common basic courses needs further attention.

At present, the transition at TU/e is still ongoing, with many more challenges to come. The second curriculum year is now being taught for the first time, the third year is still "under construction". And that is merely the undergraduate education. For its graduate education (comprising two- year MSc programmes, two-year Technological Designer programmes leading to a Professional Doctorate in Engineering (PDEng) and four-year PhD programmes), TU/e has established the TU/e Graduate School, in which these 3 types of programmes are brought together in a coherent way. Reforms for the graduate phase of TU/e education are still being developed as we speak. Core elements are likely to be:

- more attention to professional skills
- more international students
- establishment of a true academic community
- more MSc students continuing to pursue a PDEng or PhD degree
- extra challenges for excellent students
- transparent quality assurance in the PDEng and PhD
- better success rates.

While it is obvious that all these fundamental reforms are putting strain on the TU/e organisation and its academic and support staff, it is equally obvious that the aims of the reforms are worth the effort. Hopefully the encouraging first results will be followed by many more to come!

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# Education and Methodics Associations in Russian XXI-st – Century Universities

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***A.E. Vorobiev***

**The article describes the development of Education-Methodics Associations (EMA) in the Russian Federation since 1987. There are three divisions of Education-Methodics Associations including humanities and Social Sciences, Sciences and Engineering. It is relevant to establish RF Education-Methodics Association for teaching foreign students.**

**A.E. Vorobiev**

***Key words:*** *Educational and methodical association, history, development, division, formation of the new.*

At the present development stage Russian higher professional education has undergone revolutionay changes, conditioned by existing challenges [9]. These changes involve all aspects and structures of the higher institutions, including different Education- Methodics Associations (EMA).

The first Education-Methodics Association of higher education institutions was established in 1987 [10], after the first model Standard of EMA was adopted and further amended and finally adopted in 1997 (Ministry Decree in Russian Compulsory and Professional Education № 844, dated 05.05.1997 "Enforcement of Model Standard for Education-Methodics Associations of Russian Higher Education Institutions"), and then amended in 2001 ( Ministry Decree in Russian Education № 1742, dated 17.04.2001 "Enforcement of Model Standard for Education-Methodics Associations of Russian Higher Education Institutions").

In 1987 one of the first EMA in classical university education (i.e. Education and Methodics Association of USSR universities) was established within the framework of Moscow State University n.a. M. Lomonosov [15]. At present this EMA embraces more than 80 Russian State universities on a voluntary basis.

All existing Education and Methodics Associations of higher professional institutions were established as public-state associations within the Russian higher professional education system [15].

Education-Methodics Associations function in accordance with the following principles: equal rights for all involved members from different Universities, enterprises, institutions and organizations; joint leadership and publicity of resolutions.

The basic tasks of these numerous EMAs are the organization and participation in the project development of Federal education standards, curriculum

ENGINEERING EDUCATION 13'2013

models (to reinforce the corresponding training qualification and specialties), coordination of activities of scientific-teaching communities of universities, representatives of enterprises, institutions and organizations to provide education quality and shape the teaching content of higher, post-graduate and additional professional education, proposal development of competencies within higher, post-graduate and additional professional education and content of basic education programs [3].

Besides the above-mentioned aspects, Education-Methodics Associations of Russian higher education institutions participate not only in the project development of program models in core courses and engineering courses, which are included in the Federal Education Standard of Higher Professional Education (FES HPE), but also shape the courseware and list of education facilities for this or that academic process [13].

The Russian university EMAs embrace such significant tasks as the prepublication review of manuals and teaching guides for classified publication "EMA", development and assessment of regulatory and procedural documents concerning issues in education development within the Russian Federation, as well as, Russian and international conference - meeting-seminar management in collaboration with Ministry of Education and Science of the Russian Federation [15].

At present more than 82 Education-Methodics Associations (EMA) in different profiles function within the framework of 1200 Russian universities (public and non-governmental) [1]. These EMAs include all Universities within the territory of the Russian Federation (Fig.1) providing academic training in corresponding profiles (specialties).

All existing Russian EMAs can be split into three large divisions (Fig. 2) [7, 8]: Humanities and Social Sciences, Sciences and Engineering areas.

At various times these EMAs either expanded or integrated [2,12].

For example, in 1994, the existing list of Education-Methodics Associations of Higher Education Institutions was extended based on the following proposals of the Russian Ministry of Culture



**Fig. 1. Number of university-members of EMA [4]**

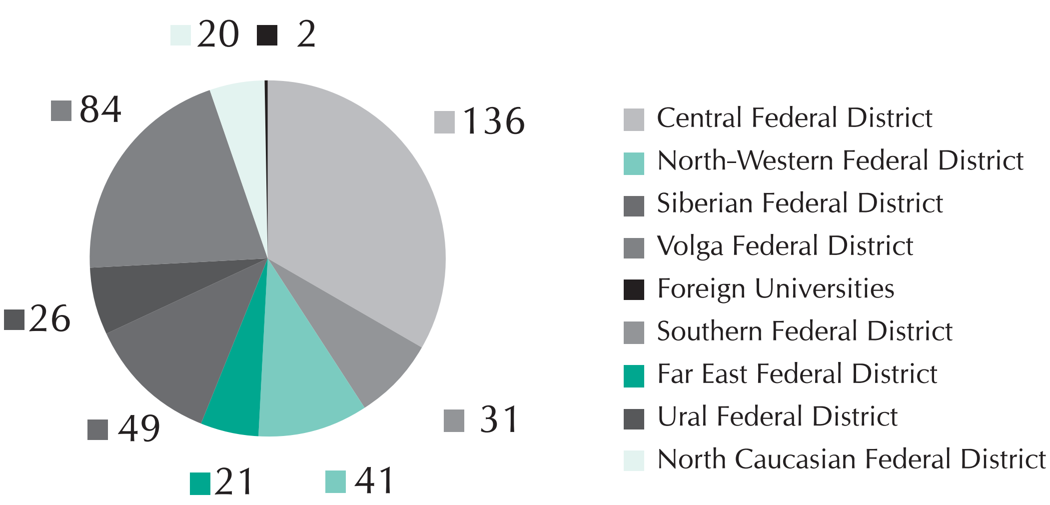


**Fig. 2. Correlation of RF EMA to different profile areas**

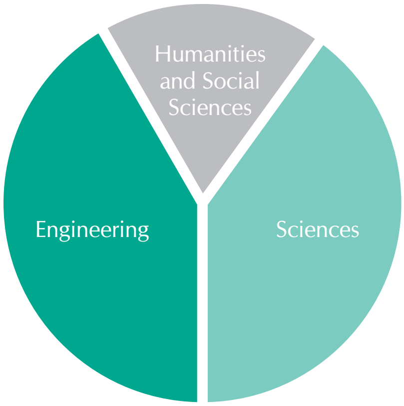
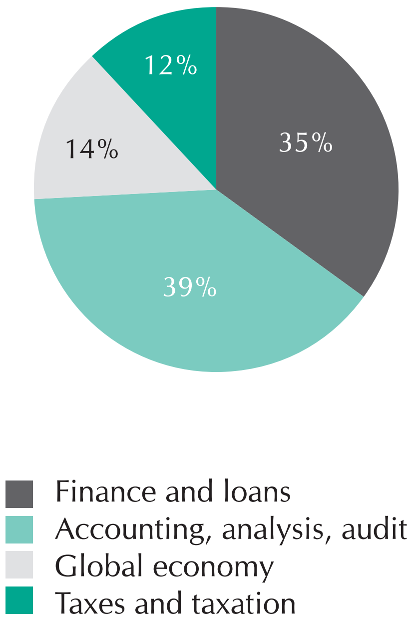



**Fig. 3. Distribution of university - members of EMA according to training profile (speciality) [4]**




and Moscow State Engineering-Physics Institute (Technical University) [2]:

- music education (basic university-Russian Academy of Music n.a. Gnesinikh);
- education in folk artistic culture, socio-cultural activites and information resources ( basic university-Moscow State Institute of Culture);
- education in nuclear technology and engineering (basic university-Moscow State Engineering-Physics Institute-Technical University)

In 2002 RF Education-Methodics Association for Naval Forces specialties (further EMA NFS) was added to the list of Education-Methodics Associations of Higher Education Institutions in Technology and Engineering and basic University EMAs (enforced Decree of Russian Ministry of Education № 3206, dated 08.11.2000), which, in its turn, was established on the base of the Baltic State Technic University "BSTU" n.a. D.F. Ustinov (St. Petersburg) [14].

Such a diversification of EMAs left specific traces on their nomenclature, content and even functions ( in spite of the non-alterable intentions of the Ministry to unify them [6]).

Every EMA includes student specialty (qualification) (Fig. 3).

The analysis of existing Russian EMAs shows that their nomenclature (determining their further profile) is rather diversified and subdivided into several taxons (Fig. 4):

- relevant to universities, as well as type of university education (for example, EMA for classical university education; EMA for university polytechnic education);
- relevant to individual academic profiles ( for example, EMA for linguistics or EMA for petroleum engineering);
- relevant to academic profiles of individual national economic sectors (EMA for fishing industry, EMA for forestry, EMA for topography and printing industry, etc.);
- relevant to innovations ( for example, EMA for innovative interdisciplinary education programs).

It should be noted that this simple designation of EMA to innovative interdisciplinary education programs does not fully reflect the essential attribute of education itself- focus on innovation.

In particular, the following profile Education-Methodics Boards were included within the framework of Education-Methodics Association for innovative interdisciplinary education programs on the basis of St. Petersburg State University (SPSU) [3]:

- 040300 (522700) – Conflict Resoluition Studies
- 031600 (522800) – Art and Humanities
- 032200 (523200) – Applied Ethics

as well as, Education-Methodics Committee in specialty:

- 010503 (351500) – Software Information and Systems Administration

All these profiles were ultimately new in those times, but at the same represent only an insignificant part of existing and potential innovative profiles (programs) for student training ( for example, experimental interdisciplinary Master Degree program "Innovation Technologies in Subsurface Management," "Audit in Subsurface Management," "Management in Petroleum Engineering" exercised in RPFU).

Education-Methodics Associations according to applied profiles could be well-defined, for example:

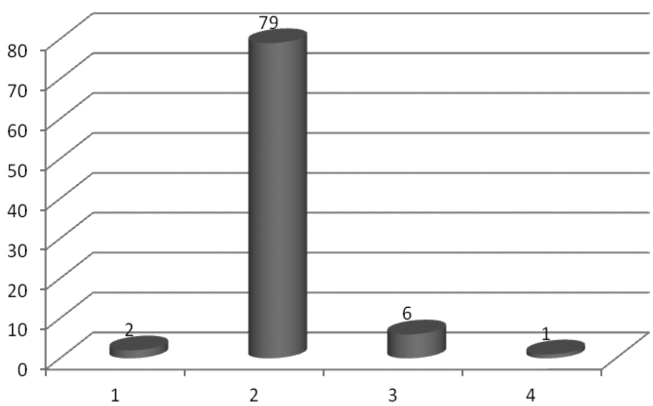
- EMA for applied mathematics and physics.
- EMA for applied mathematics and quality management.
- EMA for applied informatics.
- EMA for statistics and applied informatics.
- EMA for applied geology.

In some cases, the further development of separate Russian Education-Methodics Associations resulted in their branching off, i.e. introduction of identical EMAs in different Universities (which resulted in the fact that these universities had the right to include their specialties in the above-mentioned List, only if these specialties are included in the following notions "area of application" or " industry sector."):

- EMA for specialties in pedagogical education in MSPU (Moscow State Pedagogical University); EMA specialties in pedagogical education RSPU ( Rostov State Pedagogical University); EMA for professional pedagogical education in RSPPU (Russian State Professional-Pedagogical University).
- EMA for applied information sciences in MSU of ESIS (Moscow



**Fig. 4. Orientation of RF EMA**
**1 – university education; 2- academic; 3 – national economy sector; 4 – innovation**



State University of Economics, Statistics and Information Sciences); EMA for applied information sciences in RSHU (Russian State Humanities University).

- EMA for economics and theoretical economics in REA (Russian Economics Academy); EMA for economics and theoretical economics in SU HSE (State University- Higher School of Economics).
- EMA for mathematical methods in economics in MSU (Moscow State University); EMA for mathematical methods in economics in MSU of ESIS (Moscow State University of Economics, Statistics and Information Sciences)
- EMA for marketing in RSTEU (Russian State Trade-Economics University); EMA for marketing in SUM (State University of Management);
- EMA for management in SU HSE (State University- Higher School of Economics); EMA for management in SUM (State University of Management); EMA for management in GSU (Gulistansk State University);
- EMA in university polytechnic education in MSTU (Moscow State Technic University); EMA in university polytechnic education in SPSPU (St. Petersburg State Polytechnic Universityy).

Another important aspect is assigning EMA into international (national) components:

- EMA for foreign affairs.
- EMA for national economics and labor economics.
- EMA for finanace, audit and global economics.

Based on the analysis of the above-mentioned, the following can be concluded:

1. progressive development of the human society triggered the need of up-dated specialties and qualifications ( especially, in the case of those Universities that shape their own training profiles- i.e. national and federal universities, as well as RPFU). This, in its turn, involves the establishment of new EMAs.

2. at present there is a definite differentiation (specialty intensification) of various specialties and qualifications in students' training.

3. a range of modern specialties are included in the framework of "far-back" EMAs, which is far short of optimum.

4. It should be noted that today more than 80 thousand foreign students study in 229 Universities of the Russian Federation ( Table 1).

In this case the total (about 12 thousand students) and specific ( in different Universities) number of CIS citizens studying annually in Russia should be taken into account (Fig.5).

Foreign students' training in Russian universities has the following aspects to be considered:

(1) adaptation of foreign students includes their understanding of the new education system, which, in its turn, involves rapid and effective mastering of the Russian language [17];

(2) proper allowance must be made for those traditions, culture, regulations and requirements and production knowledge of the future employer-countries.

Above-mentioned conditions determine the requirement to establish EMAs in training foreign students within the Russian Federation. The question arises: How could such disciplines as "Foreign Law", "Russian -Foreign Language", "Geology Abroad" and other specific disciplines be assigned to corresponding Education-Methodics Committees? At the same time, such a EMA should be established within the framework of RPFU as a basic university (i.e. in view of the fact that there is internation profile).

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**Table 1. Distribution of foreign students in different specialties of Russian Universities in 2005- 2006 [5]**

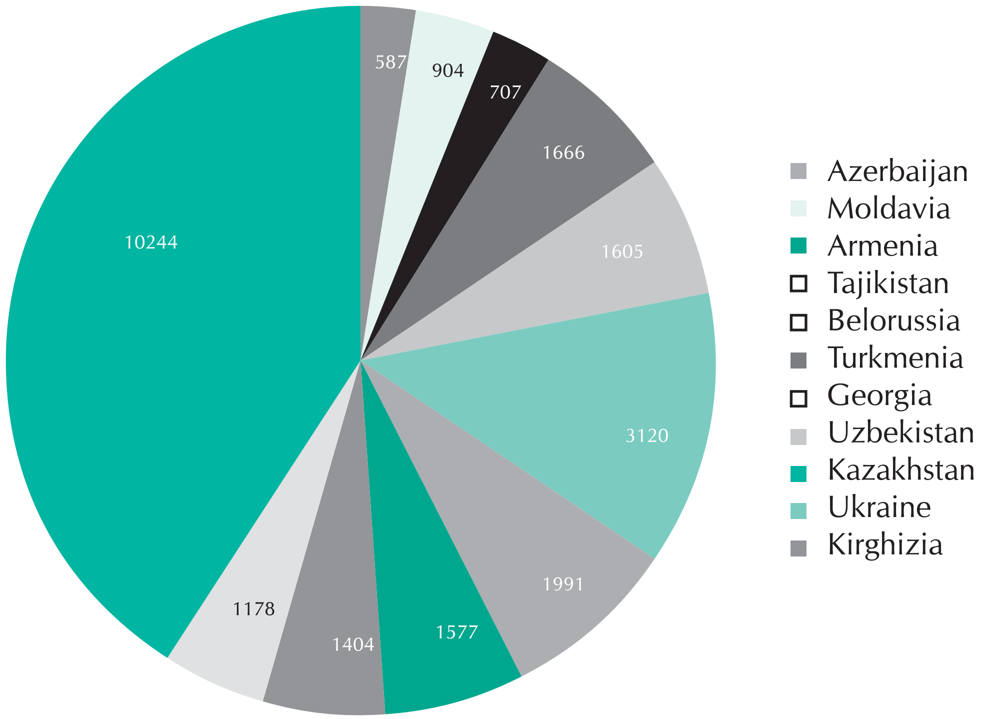
| CIS countries | The Baltics | Eastern European countries | Nordic countries (Scadinavia) | WEC | Asian countries | Middle East countries and North Africa | African countries (besides Northern) | Latin America countries | North America countries and Oceanic | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Specialty: Russian language | | | | | | | | | | |
| 1769 | 105 | 2113 | 364 | 1967 | 7352 | 378 | 184 | 134 | 951 | 15317 |
| Specialty: Medicine | | | | | | | | | | |
| 2600 | 25 | 72 | 56 | 265 | 7829 | 2363 | 1488 | 233 | 51 | 14982 |
| Specialty: Economics, finance, management | | | | | | | | | | |
| 7834 | 282 | 151 | 79 | 228 | 5270 | 278 | 683 | 112 | 34 | 14951 |
| Specialty: Humanities – Social Sciences (History, Sociology, Psychology, journalism, philosophy, philology, political science, foreign affairs and others) | | | | | | | | | | |
| 2751 | 214 | 186 | 45 | 295 | 2704 | 291 | 492 | 148 | 150 | 7276 |
| Specialty: Natural and exact sciences, science of Earth ( mathematics, physics, meterology, marine science and others), geology, geodesy, ecology and others | | | | | | | | | | |
| 2818 | 86 | 41 | 4 | 70 | 1744 | 200 | 352 | 166 | 18 | 5499 |
| Specialty: Information and computer science, automation control system | | | | | | | | | | |
| 2206 | 125 | 40 | 1 | 26 | 1689 | 502 | 451 | 81 | 2 | 5123 |
| Specialty: Law | | | | | | | | | | |
| 3179 | 71 | 80 | 7 | 65 | 465 | 76 | 145 | 34 | 9 | 4131 |
| Specialty: Culture, arts, music, physical trainin and sport | | | | | | | | | | |
| 1287 | 126 | 36 | 37 | 113 | 1666 | 110 | 41 | 33 | 51 | 3500 |
| Specialty: Energy engineering, mechanic engineering, materials processing, metallurgy | | | | | | | | | | |
| 1349 | 46 | 4 | 1 | 16 | 586 | 128 | 161 | 38 | 1 | 2330 |
| Specialty: Architecture and construction | | | | | | | | | | |
| 608 | 35 | 50 | 6 | 40 | 1018 | 162 | 230 | 53 | 4 | 2206 |
| Specialty: Electronic engineering, radio engineering and communication, optics | | | | | | | | | | |
| 1234 | 22 | 18 | 0 | 17 | 476 | 166 | 170 | 33 | 1 | 2137 |
| Specialty: Production technology of consumer products and food products | | | | | | | | | | |
| 716 | 4 | 9 | 0 | 4 | 512 | 65 | 121 | 15 | 0 | 1446 |
| Specialty: Transportation facilities and service | | | | | | | | | | |
| 616 | 72 | 1 | 0 | 1 | 405 | 63 | 102 | 28 | 0 | 1288 |
| Specialty: Aviation and aerospace technology | | | | | | | | | | |
| 218 | 5 | 5 | 0 | 50 | 571 | 26 | 45 | 34 | 2 | 956 |
| Specialty: Chemical technology | | | | | | | | | | |
| 438 | 2 | 18 | 0 | 1 | 253 | 69 | 138 | 11 | 0 | 930 |
| Specialty: Pharmaceutics | | | | | | | | | | |
| 189 | 2 | 0 | 0 | 3 | 61 | 500 | 75 | 3 | 1 | 834 |
| Specialty: Pedagogy | | | | | | | | | | |
| 391 | 18 | 4 | 5 | 13 | 194 | 8 | 14 | 4 | 14 | 665 |
| Specialty: Agriculture, forestery and fishing industry | | | | | | | | | | |
| 278 | 5 | 3 | 0 | 7 | 135 | 48 | 113 | 44 | 0 | 633 |
| Specialty: Mining | | | | | | | | | | |
| 329 | 3 | 1 | 0 | 0 | 164 | 35 | 71 | 4 | 0 | 607 |
| Specialty: Robot technology and integrated automatic control engineering, bio-medicine, bio-technology | | | | | | | | | | |
| 189 | 3 | 5 | 0 | 2 | 206 | 99 | 24 | 16 | 0 | 544 |
| Specialty: Veterinary science | | | | | | | | | | |
| 104 | 11 | 2 | 0 | 1 | 13 | 30 | 30 | 5 | 1 | 197 |
| Other specialties | | | | | | | | | | |
| 570 | 14 | 7 | 7 | 62 | 364 | 104 | 170 | 15 | 10 | 1323 |
| TOTAL | | | | | | | | | | |
| 32532 | 1276 | 2846 | 612 | 3246 | 33677 | 5701 | 5300 | 1244 | 1300 | 86875 |

the same time, such a EMA should be established within the framework of RPFU as a basic university (i.e. in view of the fact that there is internation profile).

Thus, Federal State-Funded Education Institution of Higher Professional Education "Russian University of People's Friendship" is an international classical university, the mission of which includes the following [11]:

- blending the knowledge of different nationalities, races and confessions;
- training top-priority in-demand specialists for different human activity areas;
- shaping personalities as patriots of one's country and friends of Russia being acquainted with global culture, importing ideals of humanism, democracy and people's friendship;
- fostering the young generation who would be able to work successfully in any country of the world and show one's creative abilities relevant to cross-communication of different civilizations and diversity of modern societies.

**Fig. 5. Number of foreign citizens studying in Russian universities during 2003-2004 [5]**

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# School n.a. Professor N.S. Nikolaev

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***R.R. Kopirin***

**This article is devoted to the 80th anniversary of Professor N.S. Nikolaev, founder of the Academic Olympic Movement in graphic drawing in Yakutia. It highlights the contemporary issues in technic drawing teaching in the schools of Sakha Republic (Yakutia) and describes the obtained 50-year experience in Academic technic drawing Olympic management. The author also suggests advanced development paths for effective teaching methods to improve the training quality of school technic drawing programs.**

***Key words:*** *drawing, graphic's task, school, individual approach, out-of-class work, Olympiad in drawing.*

**R.R. Kopirin**

Recently, Nikolaev Nikolai Spiridonovich celebrated his 80th anniversary (birth date 06. 03.1933). A few significant moments from his academic life should be highlighted: graduate of Moscow Polygraphic Institute in 1956-qualification "Mechanic-engineer"; Honored Teacher of Yakutia, ASSR; laureate of State Prize of Sakha Republic (Yakutia) in science and technology; Honored Member of Higher Professional Education RF; Candidate of Pedagogic Sciences; Professor of North-Eastern Federal University (NEFU); Corresponding Member of Russian Engineering Academy; war veteran; author of more than 40 manuals, monographs, guidelines and teaching aids in graphic drawing; permanent president of Yakutia Republic State Academic School Olympics.

N.S. Nikolaev started his academic activities as part-time employee in 1956, i.e. from the opening of Yakutia State University (YSU). In 1957 he became assistant professor and, at the same time, deputy Head of Strength of Materials and Engineering Graphics Department.

In 1981 independent department "Engineering Graphics" was established, the Head of which Associated Professor N.S. Nikolaev was elected, future Member of Education Board of Ministry of Higher and Vocational Secondary Education (MH&VSE) in descriptive geometry and engineering graphics and Member of Coordination Board of Main Branch of Mining Institutes, MH&VSE USSR in engineering graphics.

Specialists in engineering graphics of Yakutia State University (North-Eastern Federal University) have made quite significant contributions not only to the Republic itself, but also to RF (former USSR). For example, prominent teaching improvement of graphic disciplines (i.e. descriptive geometry, technical drawing, engineering graphics, etc.) in most education establishments, especially, secondary schools. This involved long-term systematic activities in improving the methodological level and qualification of both teachers and instructors. This was furthered through different courses, seminars, academic Olympics, competitions, etc. among teachers, supervisors of different workshops, as well as, among students of Yakutia and the Republic.

The first qualification upgrading teacher training courses in graphics and art was conducted in Yakutia in 1963 at the initiative of the Head of Graphic and Technic Drawing Department, N.S. Nikolaev. These were the first 10-day courses conducted only by N.S. Nikolaev. Students (more than 30 from different regions) were highly satisfied. These courses helped many to understand what this subject was, i.e. technic drawing and its importance for students in the country where a new infrastructure was being developed. The second (1966) and third (1969) courses were conducted within the framework of the Department itself. It should be noted that in the Yakutia Republic Extension Course Institute for Teachers (YRECIT) no one worked in the issues of technic drawing as there were no specialists, in the first place, and there was not even a department in technic drawing. In 1970 regular teacher courses in technic drawing were being conducted at the YRECIT in collaboration with specialists under the supervision of N.S. Nikolaev.

Up to 1963 N.S. Nikolaev, intuitu personae, conducted different courses, seminars and workshops for teachers of technic drawing in Yakutia to help them in their school work and to upgrade teacher qualification in order to improve the teaching level of technic drawing in schools and other education institutions (i.e. " stop spinning one's wheels"). It can be said that he "started business from scratch." He worked free of charge, i.e. pro bono publico. Technic drawing was considered to be a neglected subject throughout the country (former USSR), as there were practically no specialists at that time. One should underline the fact that the young teacher N.S. Nikolaev was one of the first graduates of Moscow Technical Institutions from Yakutia; and this could have been the reason why his ideas and initiatives were supported by the Yakutia Ministry of Education, as well as in several schools and education institutions of regional Yakutia Committee of Communist Party of the Soviet Union (CPSU). The first attempt was the so-called workshop in technic drawing for the teachers of Yakutia, which in its turn, became the first extension course for teachers of different education institutions, including secondary schools. Later, these courses were annually conducted by the Yakutia Republic Extension Course Institute for Teachers (YRECIT), and then in collaboration with staff of Engineering Graphics Department. However, this cases things for a while.

From the 1970's to Soviet collapse, associate professor N.S. Nikolaev conducted more than 100 seminars (free of charge) for teachers of technic drawing in Yakutia travelling from one region to another. More than 2000 participated in these seminars, while his courses embraced more than 3000. These seminars, courses and other workshops were organized by N.S. Nikolaev himself for the Yakutia Republic and it can be stated that they evolved into a school, SCHOOL n.a. N.S. Nikolaev.

From 1962 to 1963 the first school Academic Olympic in Yakutia was organized under the supervision of N.S. Nikolaev. The first two years this Olympic was for only school children of Yakutia, and then in 1964-1965 it was conducted as a Republic Olympic in technic drawing. In 1985 it was granted the status of State Olympic. Such Academic Olympics in technic drawing has no analog in Russia, CIS and even in the world. More than 170000 students from 300 secondary schools of 28 ulus and Yakutai have participated, among which 1415 are prize-winners and runnerrs-up from 105 schools of the Yakutia Republic. Another interesting fact is that more than 200 students from Belorussia, Georgia, Stavropol Territory, Kursk have also participated in these Olympics, either in presentio or in absentia. It is outstanding that these Olympics have been generally recognized.

Many talented and outstanding specialists – engineers, architects, teachers, internationally recognized scientists and even public officials ( S.N. Nazarov, A.V. Migalkin, T.T. Savvinov and many others) were among the prize-winners of Professor N.S, Nikolaev Olympics (i.e. these Olympics are called "Nikolaev Olympics").

Based on the results of these Olympics and his own personal experience, N.S. Nikolaev began to organize such Olympics in Belorussia, Goergia, Ukraine and in some districts of Moscow and other RF cities (Mineralnye Vody, Kursk, Smolensk and others). Delegates from Georgia (1974), Moscow (1970, 1971, 1981, 1990), Stavropol Territory (1984) and other RF cities studied the experience practice (know-how) in organizing technic drawing Olympics.

It is notable that the USSR Board of Education studied and discussed the obtained experience in organizing and conducting Yakutia Republic School Olympics in technic drawing. Based on the results presented by Professor N.S. Nikolaev (1975 and 1978), special resolutions were adopted to distribute and promote this exclusive experience in Yakutia. According to above-mentioned facts, the following three books were published by Publishing House "Prosveschenie": (1) N. Nikolaev (1981) Implementation of Olympics in Technic Drawing; P. 4, circulation- 3900; (2) V. Okoneshnikov (1984) Technic Drawing Classroom; P. 4, circulation- 3900; (3) N. Nikolaev (1990) Implementation of Olympics in Technic Drawing; P. 10, circulation- 60000. These books were adopted by the USSR Ministry of Education as a teacher manual, and even, today, it is still considered to be reference books for all teachers throughout the Russian Federation and CIS.

It goes without saying that not one book has been published on above-mentioned topics yet.

In 1979 under the supervision of Professor N.S. Nikolaev the Yakutia Student Scientific Society (YSSS) in technic drawing was organized within the framework of Yakutia Republic Young Engineer Center, YR Ministry of Education. It should be highlighted that there was no analog in the USSR, and there is no analog today in RF and CIS. This society successfully existed before the Soviet collapse. It is well-known that many members of YSSS became prize-winners of State Olympics and further became outstanding specialists (engineers, teachers, etc.) and numerous recognized people of Yakutia, who are significantly grateful to their teachers - N.S. Nikolaev, V.N. Okoneshnikov, V.P. Vasilev, V.S. Chirikov and other honoured teachers of Yakutia ASSR, Republic of Sakha (Yakutia).

As a result of long-term systematic teaching improvement of technic drawing in Yakutia education institutions, unprecedented results were achieved. Knowledge and skills in technic drawing of secondary school students and students of education institutions rose to a level incomparable with other RF regions and CIS. There is a prolific in talented teachers of technic drawing throughout the Republic of Sakha (Yakutia) who are graduates of the School n.a. N.S. Nikolaev. Among them are: three honoured teachers of RSFSR and RF; seven -honoured teachers of Republic of Sakha (Yakutia); six- Companions of USSR and RF Orders and Medals, including V.V. Sivtshev awarded Order of People's Friendship; two- honorar citizens of ulus, Republic of Sakha (Yakutia); ten- teacher instructors, Republic of Sakha (Yakutia); one- Doctor of Science; 2-professors; seven- Candidates of Science and associate professors; about 40- exemplary teachers of RSFSR and RF; seven- Companions of Gold Medal n.a. V.P. Larionov, laureates of Foundation of Culture, Education and Science Development in Republic of Sakha (Yakutia).

It is gratifing to emphasize the fact that practically most technic drawing teachers in Republic of Sakha (Yakutia) schools consider themselves to be the followers of prof. N.S. Nikolaev. All the teachers in technic drawing, descriptive geometry and engineering graphics of Yakutia education institutions are proud to state that "their" N.S. Nikolaev was pronounced as one of the 2900 eminent scientists and specialists in Russia, printed in Russian Internet – encyclopedia (www. famous – scientists.ru/1158). This fact shows the recognition of world scientists for Professor's achievements in domestic science. He was awarded the badge "Eminent Scientists of Russia" and certificate as participate of INTERNET-Encyclopedia "Eminent Scientists of Russia" (2007-Sochi).

It was vulgarly supposed that if you are a Yakut-you are either a hunter or fisher; in the war years: if you are a Yakut – you are an expert sniper; after war years: if you are a Yakut – you are either an artist or writer and today students say that if you are a Yakut – you are an excellent (outstanding) draftsman. These homely phrases could be possible due to the significant achievements of technic drawing teachers of Yakutia, followers of professor N.S. Nikolaev.

It is not likely that everyone knows such a fact: prof. N.S. Nikolaev was not only a corresponding member of Russian Engineering Academy, a delegate of the First Russian Engineering Congress in Moscow (Kremlin Palace, 2003), but also a participant at the Fifth Forum of Engineers "Planet" in Paris, France (May, 2004). N.S. Nikolaev is the First Yakut Professor in descriptive geometry, which in its turn, was developed by Gaspard Monge, the author of the first textbook in descriptive geometry, the first French professor and academician (one of the closest comrade-in-arms of Napoleon Bonaparte). These facts are by no means accidental or deliberate because no one can be a delegate of such a historical congress and respectable Engineering Forum without due cause. We are proud that we are working side-by-side with professor N.S. Nikolaev, whose SCHOOL is recognized as a top-ranking one throughout the world.



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# Summary

## FORMING COMPETENCES FOR GENERATING NEW IDEAS – BASIS OF COMPLEX ENGINEERING EDUCATION

S.A. Podlesnyi, A.V. Kozlov
Siberian Federal University

The paper examines the structure of modern knowledge, abilities and skills required for generating new ideas. Based on up-to-date approaches, didactic and information technologies have been proposed.

## "FORMULA-STUDENT" PROJECT AS A PLATFORM FOR PRACTICE-ORIENTED TRAINING OF ENGINNERING GRADUATES

V.V. Yeltsov, A.V. Skripachev
Togliatti State University

Practice-oriented training, an innovative teaching technology, is one of the conditions for quality assurance in Higher Education. Such innovative international "Formula-Student" project, combining education, science and sport, is being implemented at Togliatti State University.

## PRACTICAL COMPETENCES AS LEARNING OUTCOMES USING CES EDUPACK

T. Vakhitova, C. Fredriksson
Granta Design Limited, Cambridge, UK

The quality of modern engineering education is measured in terms of learning outcomes. This holds true for, e.g., the ABET accreditation system and the CDIO Syllabus. This paper demonstrates how a computer-based teaching resource, CES EduPack, could be used by Universities towards learning outcomes necessary for accreditation of engineering programmes.

## "RISK-MANAGEMENT" AND "RISK OF MANAGEMENT" AS PHENOMENON OF CONTINUING PROFESSIONAL EDUCATION

N.V. Samsonova, E.S. Minkova
Immanuel Kant Baltic Federal University

The paper examines the concept «challenging professional environment» as an obligatory component of continuing professional education, analyzes the risks inherent in workplace-related and person-related sub-systems as a special group of risks in professional micro environment, and outlines the concepts "risk-management" and "risk of management" which constitute the conceptual basis of continuing professional education programs.

## TOOLS AND INDICATORS FOR A DYNAMICAL, INNOVATIVE AND OPTIMIZED EDUCATION PROGRAM

S. Flament
ENSICAEN, Grande Ecole, Caen, France

Table and indicators which allow a rapid analysis and comparison of education programs are presented. Among them, the matrix of competences is very useful to check that targeted skills are really fulfilled by the education program. In addition to the analysis of the curriculum, benefits, limits and opportunities provided by innovative learning process like Project Oriented Learning, Reverse Engineering Learning and Online courses are discussed.

## INTELLIGENT DATA ANALYSIS IN QUALITY MANAGEMENT PROBLEMS OF EDUCATION PROCESS

G.J. Soltan, S.S. Smailova, I.M. Uvalieva
D. Serikbayev East Kazakhstan State Technical University
A.K. Tomilin
National Research Tomsk Polytechnic University

The article describes the Intelligent Data Analysis (IDA) system model applied to the University education process, the possiblities of IDA in consideration of the characteristic education aspects and its application.

## ORGANISING EDUCATIONAL AND TRAINING PROCESS IN COOPERATION WITH EMPLOYERS

N.I. Senin, M.N. Popova
National Research Moscow State University of Civil Engineering

Best practices of university interaction with employers within the educational process are presented. The paper describes an example of cooperation between the Institute of Civil Engineering and Architecture (MGSU) and employers – the construction enterprises in Moscow and Moscow region. Some forms of joint projects that improve  the quality of students' training are given.

## ABILITY TOWORK IN PROFESSIONAL COMMUNITY AS UNIVERSAL COMPETENCE OF A MODERN ENGINEER

I.G. Kartushina
Immanuel Kant Baltic Federal University

The author analyzes the meaning of "competence for collective work» as engineers ability to work in professional community. She reveals the content and structure of the competence, discovers its influence on whole pedagogical process in higher education.

## TECHNICAL MECHANICS WITHIN THE TECHNOLOGY TEACHER TRAINING SYSTEM

V. Luzhetsky, Yu. Pavlovsky
Drohobych Ivan Franko State Pedagogical University, Ukraine

Based on the theoretical analysis and practical experience in grounded circuit integration, the course Technical Mechanics has eliminated the possible duplication of technical disciplines within the technology teacher training system.

## LEARNING MOTIVATION OF ENGINEERING UNIVERSITY STUDENTS BY MEANS OF PEDAGOGICAL SUPPORT OF EDUCATION

U.V. Podpovetnaya
South Ural State University

Pedagogical support of student's training is a key factor influencing the process of learning student's motivation in an engineering university. This process is focused on formation of educated people meeting socially valuable requirements of the society. The given article reveals the conditions of educational environment in an engineering university focused on student's learning motivation, presents the characteristic of pedagogical support in engineering university student's training, analyzes the human resource of a subject in pedagogical support of student's training.

## IMPLEMENTATION OF ORGANIZATIONAL AND PEDAGOGICAL CONDITIONS FOR END-TO-END COURSE PROJECT TECHNOLOGY

L.A. Kulgina
Bratsk State University

To meet the FSES requirements on competence development in the frame of Bachelor's Degree programs in civil construction it is necessary to technologize a training process and use an integrative approach to course project. The solution could be an end-to-end course project (EECP) technology including the following tools: the structural-logic scheme of the EECP content; EECP procedure; graphical description of the process; the diagnostic tools; the mathematical model of learning activity correction, etc.

### EDUCATIONAL PROCESS AT THE FEDERAL UNIVERSITY AS A BASIS TO IMPLEMENT INNOVATIVE PRACTICE-ORIENTED EDUCATIONAL TECHNOLOGIES

N.S. Buryanina, A.A. Pshennikov
North East Federal University
I.S. Lysenkov
CJSC "Optogan"
E.V. Lesnykh
Siberian Transport University

The article sets a principle goal – to change the traditional system of engineerring education by implementation of flexible practice-oriented and project-based educational technologies by the example of North-Eastern Federal University n.a. Ammosov

### APPROACHES AND METHODS FOR MOTIVATION DEVELOPMENT AT UNIVERSITY

L.M. Semenova
South Ural State University

The article deals with pedagogical technologies, innovative approaches and methods of work with students, motivating them to be engaged more in the training process.

### ACTIVITIES-BASED TEACHING TO BUILD ENVIRONMENTAL COMPETENCE OF STUDENTS

L.S. Nasrutdinova
Tyumen State Oil and Gas University

The article presents the analysis of various definitions of the concept "environmental competence", which were suggested by different authors. The author of the paper suggests a new definition of the concept "environmental competence". The matter of activities-based approach has been revealed. The basic methods to apply activities-based approach to build environmental competence of students have been described.

### QUALITY MANAGEMENT OF PROJECT DEVELOPMENT PROCESS

E.A. Shepeleva,
I.A. Kuznetsova, E.A. Shepelev
Northern (Arctic) Federal University n.a. M. Lomonosov

Based on performed analysis concerning the notion "project development", quality determination criteria of design products, classification of projects designed in universities and possible quality management tools applied in the project development process, application requirements are proposed for specific sub-processes with further operations manuals.

### SUSTAINABLE TECHNOLOGICAL FACILITIES IN ESPC EDUCATIONAL INSTITUTIONS AS A FACTOR OF EFFICIENCY AND QUALITY IMPROVEMENT OF ENGINEERING EDUCATION

M.A. Tarasova
State University – Education-Science-Production Complex

The article presents and proves scientific concept of sustainable technological facilities development in integrated scientific-educational institutions aimed at improving quality and efficiency of engineering education.

### ADVANCED DEVELOPMENT OF ENGINEERING EDUCATION IN RUSSIA

L.B. Khoroshavin
Academy of Technological Sciences
T.A. Badyina
Ural State Mining University

The article deals with modern conditions of the education in Russia including engineering education and its development perspectives. The design of the best in the World Russian education completely free at all levels with restoration of a Teacher's status has been suggested for improving the unity and advanced development of Russia. The finite purpose is

to increase the living quality of Russian people by modernization of the country.

### IMPROVING EDUCATIONAL ACTIVITY AT BELGOROD STATE NATIONAL RESEARCH UNIVERSITY BASED ON THE CONCEPT OF PRACTICE-ORIENTED LEARNING

A.V. Mamatov, A.N. Nemtsev, L.A. Kadutskaya
Belgorod State National Research University

The efficiency of university – employer cooperation could be evaluated by such indicators as the degree of compliance of graduates training quality with the employers' requirements, demand for graduates in the labour market and the efficient use of human resources. Creating conditions for successful implementation of practice-oriented learning in the system of vocational education, will enhance the competitiveness of graduates in the labour market and strengthen position of higher education institution in system of vocational education.

### ENGINEERING EDUCATION 2.0: THE EINDHOVEN CASE

D.J.W.M. Mulders
Tilburg University, Eindhoven University of Technology, Netherlands

In response to complaints from industry in the 1990-s that engineering graduates had been educated too theoretically, Eindhoven University of Technology first developed the concept of Design-Based Learning, which was successfully implemented from the year 2000. More recent developments, both globally and locally, necessitated a more fundamental reform of all TU/e education. In 2012 a totally new design of BSc education was put in place, with encouraging results thus far. More reforms, including graduate studies, are underway.

### EDUCATION AND METHODICS ASSOCIATIONS IN RUSSIAN XXI-ST – CENTURY UNIVERSITIES

A.E. Vorobiev
Russian People's Friendship University

The article describes the development of Education – Methodics Associations (EMA) in the Russian Federation since 1987. There are three divisions of Education-Methodics Associations including humanities and Social Sciences, Sciences and Engineering. It is relevant to establish RF Education-Methodics Association for teaching foreign students.

### SCHOOL N.A. PROFESSOR N.S. NIKOLAEV

R.R. Kopyrin
North-Eastern Federal University

This article is devoted to the 80th anniversary of Professor N.S. Nikolaev, founder of the Academic Olympic Movement in graphic drawing in Yakutia. It highlights the contemporary issues in technic drawing teaching in the schools of Sakha Republic (Yakutia) and describes the obtained 50-year experience in Academic technic drawing Olympic management. The author also suggests advanced development paths for effective teaching methods to improve the training quality of school technic drawing programs.

# Public-Professional Accreditation of Curricula (Results)

Russian Association of Engineering Education (AEER) has been involved in the development and progression of public-professional accreditation system of engineering and technology programs within Russia during the last 10 years. The following issues were embraced: the study of international experience history and the development of assessment criteria and requirements for engineering and technology programs, pursuant to existing international requirements. Further, Russia, represented by AEER, was admitted to the international Alliance ENA EE (European Network for Accreditation of Engineering Education). AEER was entitled to assigning the international certification label (EUR -AC E label) for accredited programs. In view of this fact, the existing quality assessment system of education programs in Russia has been acknowledged in 14 EU countries, such as Germany, France, Great Britain, Ireland, Portugal, Turkey and others.



At the same time AEER had been taking insistent measures in entering the International Engineering Alliance Washington Accord and in 2007 AEER was included in the Alliance as associated member with Provisional signatory (website WA).

In 2012 (June 14) the International Engineering Alliance Meeting (Interim Meeting 2012, Sidney, Australia) was held, where Russia, represented by AEER, was admitted to Washington Accord (Washington Agreement) as authorized Signatory member (website WA).

Russia became the 15th Signatory- country of the Washington Agreement. This implies that all engineering education programs accredited by AEER are acknowledged by other Signatories as equivalent analogue accredited programs, including such countries as USA , Canada, Great Britain, Japan, Korea, Singapore, Ireland, Australia, South Africa and other countries.

Thus, the quality assessment system for engineering education programs developed by AEER has been acknowledged by the majority of developed countries. It can be stated that a well-developed national public-professional accreditation system for engineering education programs has been established in Russia and AEER accreditation has been internationally accepted.

Based on the results (30.06.2013) 111 EUR-ACE® labels were awarded to 192 accredited education programs from 34 Russian universities; while in Kazakhastan, 34 education programs from 7 universities were awarded EUR-ACE® Label due to international AEER accreditation.

The following Register shows the successfully accredited education programs by AEER.

# List of Accredited Programmes, Russian Federation (as of 31.12.2013)

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Altai State Technical University named after I.I. Polzunov** | | | | |
| 1. | 100400 | INT | Electrical Supply | AEER | 1997-2002 |
| 2. | 120100 | INT | Mechanical Engineering Technology | AEER | 1997-2002 |
| 3. | 120500 | INT | Welding Equipment and Technology | AEER | 1997-2002 |
| 4. | 150900 | FCD | Technology, Equipment and Automation of Mechanical Engineering Productions | AEER | 2003-2008 |
| | **Dagestan State University** | | | | |
| 1. | 210104 | INT | Microelectronics and Solid State Electronics | AEER EUR-ACE® | 2013-2018 |
| 2. | 280201 | INT | Environmental Protection and Rational Use of National Resources | AEER EUR-ACE® | 2013-2018 |
| | **Ivanovo State Power University** | | | | |
| 1. | 140404 | INT | Nuclear Power Plants and Installations | AEER EUR-ACE® | 2009-2014 |
| 2. | 210106 | INT | Industrial Electronics | AEER EUR-ACE® | 2009-2014 |
| | **Irkutsk State Technical University** | | | | |
| 1. | 130100 | INT | Aircraft and Helicopter Construction | AEER | 2004-2009 |
| 2. | 250400 | INT | Chemical Engineering of Natural Power Supplies and Carbon-base Materials | AEER | 2004-2009 |
| | **Kazan National Research Technical University named after A.N. Tupolev** | | | | |
| 1. | 150600 | FCD | Science and Technology of New Materials | AEER EUR-ACE® | 2011-2016 |
| 2. | 160100 | FCD | Aircraft Construction and Rocket Production | AEER EUR-ACE® | 2011-2016 |
| 3. | 230100 | FCD | Computer Science | AEER EUR-ACE® | 2011-2016 |
| | **Kazan National Research Technological University** | | | | |
| 1. | 240100 | FCD | Chemical Technology and Biotechnology | AEER | 2004-2009 |
| 2. | 240100 | SCD | Chemical Engineering for Innovative Entrepreneurship | AEER EUR-ACE® | 2013-2018 |
| | **Kemerovo Institute of Food Science and Technology** | | | | |
| 1. | 240700 | FCD | Food Biotechnology | AEER EUR-ACE® | 2013-2018 |
| | **Krasnoyarsk State Technical University** | | | | |
| 1. | 200700 | INT | Radio Engineering | AEER | 1997-2002 |
| 2. | 220100 | INT | Computers, Systems and Networks | AEER | 1997-2002 |
| 3. | 210302 | INT | Radio Engineering | AEER | 2003-2008 |
| | **Komsomolsk-on-Amur State Technical University** | | | | |
| 1. | 140600 | FCD | Electrical Engineering, Electromechanics and Electrical Technology | AEER | 2005-2010 |
| 2. | 140601 | INT | Electromechanics | AEER | 2005-2010 |
| 3. | 140604 | INT | Electrical Drives and Automated Industrial Sets and Engineering Systems | AEER | 2005-2010 |
| | **Moscow State Technological University "Stankin"** | | | | |
| 1. | 120100 | INT | Mechanical Engineering Technology | AEER | 1993-1998 |
| 2. | 120200 | INT | Metal-cutting Machines and Tools | AEER | 1993-1998 |
| 3. | 120400 | INT | Machines and Metal Forming Technology | AEER | 1993-1998 |
| 4. | 210200 | INT | Automation of Technological Processes and Manufacturing | AEER | 1993-1998 |
| 5. | 210300 | INT | Robots and Robotic Systems | AEER | 1993-1998 |
| 6. | 220300 | INT | Automated Production Systems | AEER | 1993-1998 |
| | **Moscow State Mining University** | | | | |
| 1. | 090400 | INT | Mine and Underground Construction | AEER | 1996-2001 |
| 2. | 090500 | INT | Open-pit Mining | AEER | 1996-2001 |
| 3. | 130408 | INT | Mine and Underground Construction | AEER EUR-ACE® | 2010-2015 |
| | **Moscow State University of Applied Biotechnology** | | | | |
| 1. | 070200 | INT | Low Temperature Physics and Technology | AEER | 1996-2001 |
| 2. | 170600 | INT | Food Production Machines and Devices | AEER | 1996-2001 |
| 3. | 210200 | INT | Automation of Technological Processes and Manufacturing | AEER | 1996-2001 |
| 4. | 250600 | INT | Plastic and Elastoplastic Processing Technology | AEER | 1996-2001 |
| 5. | 270900 | INT | Meat and Meat Products Technology | AEER | 1996-2001 |
| 6. | 271100 | INT | Milk and Dairy Products Technology | AEER | 1996-2001 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Moscow State Institute of Radio Engineering, Electronics and Automation (Technical University)** | | | | |
| 1. | 210302 | INT | Radio Engineering | AEER | 2004 -2009 |
| 2. | 220402 | INT | Robots and Robotic Systems | AEER | 2005-2010 |
| 3. | 200203 | INT | Optoelectronic Devices and Systems | AEER | 2005-2010 |
| 4. | 220401 | INT | Mechatronics | AEER | 2005-2010 |
| 5. | 210104 | INT | Microelectronics and Solid State Electronics | AEER EUR-ACE® | 2005-2010 |
| 6. | 230105 | INT | Computer Technology and Automated Systems Software | AEER | 2005-2010 |
| 7. | 230201 | INT | Information Systems and Technologies | AEER | 2005-2010 |
| 8. | 230101 | INT | Computers, Systems and Networks | AEER EUR-ACE® | 2008-2013 |
| 9. | 210104 | INT | Microelectronics and Solid State Electronics | AEER EUR-ACE® | 2010-2015 |
| 10. | 200200 | FCD | Optical Engineering | AEER EUR-ACE® | 2010-2015 |
| 11. | 210300 | FCD | Radio Engineering | AEER EUR-ACE® | 2010-2015 |
| 12. | 211000 | SCD | Quality Assurance and Certification of Electronic Equipment | АИОР EUR-ACE® | 2013-2018 |
| 13. | 210100 | SCD | Measurement and Information Technologies and Systems | АИОР EUR-ACE® | 2013-2018 |
| | **Moscow Institute of Electronic Technology (Technical University)** | | | | |
| 1. | 210100 | FCD | Electronics and Microelectronics | AEER | 2003-2008 |
| 2. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| | **National Research University of Electronic Technology (MIET)** | | | | |
| 1. | 140600 | FCD | Electrical Engineering, Electromechanics and Electrical Technology | AEER | 2005-2010 |
| 2. | 140602 | INT | Electrical and Electronic Machines | AEER EUR-ACE® | 2007-2012 |
| 3. | 140604 | INT | Electrical Drives and Automated Industrial Sets and Engineering Systems | AEER EUR-ACE® | 2007-2012 |
| 4. | 140609 | INT | Electrical Equipment for Aircraft | AEER EUR-ACE® | 2007-2012 |
| 5. | 140611 | INT | Insulators, Cables and Capacitors | AEER EUR-ACE® | 2007-2012 |
| 6. | 140403 | INT | Technical Physics of Thermonuclear Reactors and Plasma Installations | AEER EUR-ACE® | 2010-2015 |
| | **«MATI» -Russian State Technological University** | | | | |
| 1. | 190300 | INT | Aircraft instruments, Measuring and Computing complexes | AEER | 1996-2001 |
| 2. | 110400 | INT | Foundry of Ferrous and Non-ferrous Metals | AEER | 1996-2001 |
| 3. | 110500 | INT | Metal Science and Thermal Treatment of Metals | AEER | 1996-2001 |
| 4. | 110700 | INT | Welding Metallurgy | AEER | 1996-2001 |
| | **National Research Tomsk Polytechnic University** | | | | |
| 1. | 071600 | INT | High Voltage Engineering and Physics | AEER | 1996-2001 |
| 2. | 080200 | INT | Geology and Prospecting of Mineral Resources | AEER | 1996-2001 |
| 3. | 180100 | INT | Electromechanics | AEER | 1996-2001 |
| 4. | 200400 | INT | Industrial Electronics | AEER | 1996-2001 |
| 5. | 210400 | INT | Applied Mathematics | AEER | 1996-2001 |
| 6. | 250900 | INT | Chemical Engineering of Modern Energetic Materials | AEER | 1999-2004 |
| 7. | 250800 | INT | Chemical Engineering of Refractory Non-Metal and Silicate Materials | AEER | 2000-2005 |
| 8. | 070500 | INT | Nuclear Reactors and Power Plants | AEER | 2000-2005 |
| 9. | 220100 | INT | Computer Science | AEER | 2000-2005 |
| 10. | 100500 | INT | Thermal Power Plants | AEER | 2000-2005 |
| 11. | 101300 | INT | Boiler and Reactor Engineering | AEER | 2000-2005 |
| 12. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| 13. | 140600 | FCD | Electrical Engineering, Electromechanics and Electrical Technology | AEER | 2003-2008 |
| 14. | 140601 | INT | Electromechanics | AEER | 2004-2009 |
| 15. | 140604 | INT | Electrical Drives and Automated Industrial Sets and Engineering Systems | AEER | 2004-2009 |
| 16. | 230101 | INT | Computers, Systems and Networks | AEER | 2004-2009 |
| 17. | 020804 | INT | Geoecology | AEER | 2004-2009 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 18. | 130100 | FCD | Geology and Prospecting of Mineral Resources | AEER | 2005-2010 |
| 19. | 200106 | INT | Measurement Devices and Technologies | AEER EUR-ACE® | 2007-2012 |
| 20. | 200203 | INT | Opto-Electronic Equipment and Systems | AEER EUR-ACE® | 2007-2012 |
| 21. | 240304 | INT | Chemical Engineering of Refractory Non-Metal and Silicate Materials | AEER EUR-ACE® | 2007-2012 |
| 22. | 240901 | INT | Biotechnology | AEER EUR-ACE® | 2008-2011 |
| 23. | 140200 | FCD | Electrical Power Engineering | AEER EUR-ACE® | 2008-2013 |
| 24. | 150917 | SCD | High-technology Physics in Mechanical Engineering | AEER EUR-ACE® | 2008-2013 |
| 25. | 230100 | FCD | Computer Science | AEER EUR-ACE® | 2008-2013 |
| 26. | 140600 | FCD | Electrical Engineering, Electromechanics and Electrical Technology | AEER EUR-ACE® | 2008-2013 |
| 27. | 140200 | SCD | High Voltage Engineering and Physics | AEER EUR-ACE® | 2010-2015 |
| 28. | 130100 | SCD | Groundwater Resources Formation and Composition | AEER EUR-ACE® | 2010-2015 |
| 29. | 150900 | FCD | Technology, Equipment and Automation of Mechanical Engineering Productions | AEER EUR-ACE® | 2011-2016 |
| 30. | 220301 | INT | Automation of Technological Processes and Manufacturing (Gas and Oil field) | AEER EUR-ACE® | 2011-2016 |
| 31. | 210100 | SCD | Physical Electronics | AEER EUR-ACE® | 2011-2016 |
| 32. | 140200 | SCD | Mode Control of Electric Power Systems | AEER EUR-ACE® | 2011-2016 |
| 33. | 140400 | SCD | Electrical Drives and Electrical Drive Control Systems | AEER EUR-ACE® | 2011-2016 |
| 34. | 200100 | SCD | Stabilization and NavigationSystems | AEER EUR-ACE® | 2011-2016 |
| 35. | 130500 | FCD | Petroleum Engineering | AEER EUR-ACE® | 2011-2016 |
| 36. | 130500 | SCD | Geologic-geophysical Problems of Oil and Gas Field Development | AEER EUR-ACE® | 2011-2016 |
| 37. | 140801 | INT | Electronics and Automated Physical Installations | AEER EUR-ACE® | 2012-2017 |
| 38. | 240501 | INT | Chemical Technology of Modern Power Engineering Materials | AEER EUR-ACE® | 2012-2017 |
| 39. | 140404 | INT | Nuclear Power Plants and Installations | AEER EUR-ACE® | 2012-2017 |
| 40. | 200100 | SCD | Devices and Methods of Quality Control and Diagnostics | AEER EUR-ACE® | 2012-2017 |
| 41. | 200100 | FCD | Measurement Devices and Technologies | AEER EUR-ACE® | 2012-2017 |
| 42. | 200100 | FCD | Equipment Engineering | AEER EUR-ACE® | 2012-2017 |
| 43. | 200100 | FCD | Devices and Methods of Quality Control and Diagnostics | AEER EUR-ACE® | 2012-2017 |
| 44. | 200100 | SCD | Measurement Devices and Technologies of Nondestructive Testing | AEER EUR-ACE® | 2012-2017 |
| 45. | 240100 | FCD | Chemical Engineering of Natural Power Supplies and Carbon-base Materials | AEER EUR-ACE® | 2012-2017 |
| 46. | 240100 | FCD | Chemical Technology of Organic Substances | AEER EUR-ACE® | 2012-2017 |
| 47. | 240100 | FCD | Chemical Technology of Inorganic Substances | AEER EUR-ACE® | 2012-2017 |
| 48. | 240100 | FCD | Polymer Processing Technology | AEER EUR-ACE® | 2012-2017 |
| 49. | 240100 | FCD | Technology of Refractory Non-Metal and Silicate Materials | AEER EUR-ACE® | 2012-2017 |
| 50. | 240100 | SCD | Chemical Engineering of Refractory Non-Metal and Silicate Materials | AEER EUR-ACE® | 2012-2017 |
| 51. | 150100 | SCD | Science and Technology of Nanomaterials and Coatings | AEER EUR-ACE® | 2012-2017 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 52. | 200400 | FCD | Opto-Electronic Equipment and Systems | AEER EUR-ACE® | 2012-2017 |
| 53. | 022000 | FCD | Geoecology | AEER EUR-ACE® | 2012-2017 |
| 54. | 201000 | FCD | Biotechnical and Medical Devices and Systems | AEER EUR-ACE® | 2012-2017 |
| | **National Research University «Belgorod State University»** | | | | |
| 1. | 210400 | FCD | Telecommunications | AEER EUR-ACE® | 2012-2017 |
| 2. | 210406 | INT | Communication Networks and Switching Systems | AEER EUR-ACE® | 2012-2017 |
| 3. | 210602 | INT | Nanomaterials | AEER EUR-ACE® | 2012-2017 |
| | **National University of Science and Technology «MISIS»** | | | | |
| 1. | 150101 | INT | Metallurgy of Ferrous Metals | AEER | 2004-2009 |
| 2. | 150105 | INT | Metal Science and Thermal Treatment of Metals | AEER | 2004-2009 |
| 3. | 150601 | INT | Science and Technology of New Materials | AEER | 2004-2009 |
| 4. | 150400 | FCD | Metallurgy of Ferrous Metals | AEER EUR-ACE® | 2011-2016 |
| 5. | 150400 | FCD | Physical Metallurgy of Non-Ferrous, Rare-Earth and Precious Metals | AEER EUR-ACE® | 2011-2016 |
| 6. | 150400 | FCD | Functional Materials and Coatings | AEER EUR-ACE® | 2011-2016 |
| 7. | 150400 | FCD | Metal Forming | AEER EUR-ACE® | 2011-2016 |
| 8. | 011200 | FCD | Physics of Condensed Matter | AEER EUR-ACE® | 2012-2017 |
| 9. | 150100 | FCD | Materials Science and Engineering of Functional Materials for Nanoelectronics | AEER EUR-ACE® | 2012-2017 |
| 10. | 150400 | FCD | Metallurgy of Non-ferrous, Rare and Precious Metals | AEER EUR-ACE® | 2012-2017 |
| 11. | 151000 | FCD | Metallurgical Machines and Equipment | AEER EUR-ACE® | 2012-2017 |
| 12. | 210100 | FCD | Semiconductor Devices for Micro- and Nanoelectronics | AEER EUR-ACE® | 2012-2017 |
| 13. | 210100 | FCD | Materials and Technologies of Magnetoelectronics | AEER EUR-ACE® | 2012-2017 |
| 14. | 210100 | FCD | Micro- and Nanotechnology Processes | AEER EUR-ACE® | 2012-2017 |
| 15. | 220700 | FCD | Automated Systems in Manufacturing | AEER EUR-ACE® | 2012-2017 |
| 16. | 230100 | FCD | Automated Systems | AEER EUR-ACE® | 2012-2017 |
| | **Novosibirsk State Technical University** | | | | |
| 1. | 150501 | INT | Materials Science in Mechanical Engineering | AEER EUR-ACE® | 2012-2017 |
| | **Peoples' Friendship University of Russia** | | | | |
| 1. | 270100 | SCD | Structural Theory and Engineering | AEER EUR-ACE® | 2013-2018 |
| 2. | 270100 | SCD | River and Underground Hydraulic Engineering Works | AEER EUR-ACE® | 2013-2018 |
| 3. | 270100 | SCD | Theory and Practice of Organizational, Technical and Economic Decisions in Building and Construction | AEER EUR-ACE® | 2013-2018 |
| 4. | 141100 | SCD | Internal Combustion Engines | AEER EUR-ACE® | 2013-2018 |
| 5. | 141100 | SCD | Steam- and Gas Turbine Plants and Engines | AEER EUR-ACE® | 2013-2018 |
| | **Samara State Aerospace University** | | | | |
| 1. | 160301 | INT | Aircraft Engines and Power Plants | АИОР EUR-ACE® | 2008-2013 |
| 2. | 160802 | INT | Spasecraft and Rocket Boosters | АИОР EUR-ACE® | 2008-2013 |
| | **Saint Petersburg Electrotechnical University "LETI"** | | | | |
| 1. | 220200 | FCD | Automation and Control | AEER | 2003-2008 |
| 2. | 210100 | FCD | Electronics and Microelectronics | AEER | 2003-2008 |
| 3. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| 4. | 200300 | FCD | Biomedical Engineering | AEER | 2003-2008 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Siberian State Aerospace University** | | | | |
| 1. | 220100 | FCD | System Analysis and Control | AEER EUR-ACE® | 2011-2016 |
| 2. | 230100 | FCD | Computer Science and Computer Facilities | AEER EUR-ACE® | 2011-2016 |
| | **Siberian Federal University** | | | | |
| 1. | 210200 | SCD | Microwave Equipment and Antennas | AEER EUR-ACE® | 2010-2015 |
| 2. | 230100 | SCD | High-Performance Computing Systems | AEER EUR-ACE® | 2010-2015 |
| | **Stary Oskol Technological Institute named after A.A. Ugarov (branch of National University of Science and Technology «MISIS»)** | | | | |
| 1. | 150400 | FCD | Metallurgy of Ferrous Metals | AEER EUR-ACE® | 2012-2015 |
| | **Taganrog Institute of Technology of Southern Federal University** | | | | |
| 1. | 210100 | FCD | Electronics and Microelectronics | AEER | 2003-2008 |
| 2. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| 3. | 230100 | FCD | Computer Science | AEER EUR-ACE® | 2010-2015 |
| 4. | 220200 | FCD | Automation and Control | AEER EUR-ACE® | 2010-2015 |
| 5. | 210100 | FCD | Electronics and Microelectronics | AEER EUR-ACE® | 2012-2017 |
| 6. | 200100 | FCD | Equipment Engineering | AEER EUR-ACE® | 2012-2017 |
| | **Tambov State Technical University** | | | | |
| 1. | 210201 | INT | Design and Technology of Radioelectronic Devices | AEER | 2006-2011 |
| 2. | 140211 | INT | Electrical Supply | AEER | 2006-2011 |
| | **Togliatty State University** | | | | |
| 1. | 140211 | INT | Electrical Supply | AEER EUR-ACE® | 2009-2014 |
| 2. | 150202 | INT | Industrial Welding Technology and Equipment | AEER EUR-ACE® | 2009-2014 |
| 3. | 151002 | INT | MechanicalEngineeringTechnology | AEER EUR-ACE® | 2009-2014 |
| | **Tomsk State University of Control Systems and Radio Electronics** | | | | |
| 1. | 210100 | FCD | Electronics and nanoelectronics | AEER EUR-ACE® | 2013-2018 |
| 2. | 222000 | FCD | Innovation | AEER EUR-ACE® | 2013-2018 |
| | **Trekhgorny Technological Institute** | | | | |
| 1. | 230101 | INT | Computers, Systems and Networks | AEER | 2004-2007 |
| | **Tyumen State Oil and Gas University** | | | | |
| 1. | 130501 | INT | Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities | AEER | 2006-2011 |
| 2. | 130503 | INT | Development and Exploitation of Oil and Gas Fields | AEER | 2006-2011 |
| 3. | 130504 | INT | Oil and Gas Drilling | AEER | 2006-2011 |
| 4. | 190601 | INT | Automobiles and Transportation Facilities | AEER | 2007-2012 |
| 5. | 190603 | INT | Transport and technological machinery and equipment service (oil and gas production) | AEER | 2007-2012 |
| 6. | 190701 | INT | Transportation organization and transport management (automobile transport) | AEER | 2007-2012 |
| 7. | 130602 | INT | Oil and Gas Fields Machinery and Equipment | AEER EUR-ACE® | 2008-2013 |
| 8. | 150202 | INT | Industrial Welding Technology and Equipment | AEER EUR-ACE® | 2008-2011 |
| 9. | 190205 | INT | Lifting, Transportation Means and Road Machines | AEER EUR-ACE® | 2008-2013 |
| 10. | 240401 | INT | Chemical Technology of Organic Substances | AEER EUR-ACE® | 2009-2014 |
| 11. | 240403 | INT | Chemical Engineering of Natural Power Supplies and Carbon-base Materials | AEER EUR-ACE® | 2009-2014 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 12. | 240801 | INT | Machines and Apparatus of Chemical Production | AEER EUR-ACE® | 2009-2014 |
| 13. | 280201 | INT | Environmental control and rational use of natural resources | AEER EUR-ACE® | 2010-2015 |
| 14. | 280102 | INT | Safety of technological processes and productions | AEER EUR-ACE® | 2010-2015 |
| 15. | 120302 | INT | Landcadastre | AEER EUR-ACE® | 2010-2015 |
| | **Tyumen State University of Architecture and Civil Engineering** | | | | |
| 1. | 270800 | SCD | Water Supply and Sanitation | AEER EUR-ACE® | 2013-2018 |
| 2. | 270800 | SCD | Industrial and Civil Construction | AEER EUR-ACE® | 2013-2018 |
| 3. | 280700 | SCD | Safety of Technological Processes and Production | AEER EUR-ACE® | 2013-2018 |
| | **Ural State Forest Engineering University** | | | | |
| 1. | 270205 | INT | Automobile Roads and Aerodromes | AEER | 2006-2011 |
| | **Ural State Technical University** | | | | |
| 1. | 240302 | INT | Technology of Electrochemical Productions | AEER EUR-ACE® | 2008-2013 |
| | **Ufa State Aviation Technical University** | | | | |
| 1. | 280200 | FCD | Environment Protection | AEER | 2005-2010 |
| 2. | 230100 | FCD | Computer Science | AEER | 2005-2010 |
| 3. | 150501 | INT | Material Science in Mechanical Engineering | AEER | 2005-2010 |
| 4. | 280200 | SCD | Environment Protection | AEER EUR-ACE® | 2008-2013 |
| | **Ufa State Petroleum Technological University** | | | | |
| 1. | 130504 | INT | Oil and Gas Drilling | AEER EUR-ACE® | 2007-2012 |
| 2. | 130603 | INT | Oil and Gas Processing Equipment | AEER EUR-ACE® | 2007-2012 |
| 3. | 150400 | FCD | Processing Machinery and Equipment | AEER EUR-ACE® | 2007-2012 |
| 4. | 240100 | FCD | Chemical Engineering and Biotechnology | AEER EUR-ACE® | 2008-2013 |
| 5. | 240403 | INT | Chemical Engineering of Natural Power Supplies and Carbon-base Materials | AEER EUR-ACE® | 2008-2013 |
| 6. | 130602 | INT | Oil and Gas Fields Machinery and Equipment | AEER EUR-ACE® | 2008-2013 |
| 7. | 130501 | INT | Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities | AEER EUR-ACE® | 2009-2014 |
| 8. | 551830 | SCD | Equipment Design Theory for Oil and Gas Processing, Petrochemical and Chemical Production | AEER EUR-ACE® | 2010-2015 |
| 9. | 551831 | SCD | Technological Systems and Equipment Reliability | AEER EUR-ACE® | 2010-2015 |
| 10. | 550809 | SCD | Chemical Engineering of Fuel and Gas | AEER EUR-ACE® | 2010-2015 |
| 11. | 270100 | FCD | Building Construction | AEER EUR-ACE® | 2011-2016 |
| 12. | 550109 | SCD | Building Construction | AEER EUR-ACE® | 2011-2016 |
| 13. | 131000 | FCD | Petroleum Engineering | AEER EUR-ACE® | 2013-2018 |
| 14. | 151000 | FCD | Production Machines and Equipment | AEER EUR-ACE® | 2013-2018 |
| | **Vladimir State Universitynamed after Alexander and Nikolay Stoletovs** | | | | |
| 1. | 150900 | FCD | Technology, Equipment and Automation of Mechanical Engineering Productions | AEER EUR-ACE® | 2012-2017 |
| 2. | 230100 | FCD | Computer Science | AEER EUR-ACE® | 2012-2017 |

## List of Accredited Programs, Republic of Kazakhstan (as of 31.12.2013)

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **D. Serikbayev East Kazakhstan State Technical University (Ust-Kamenogorsk, Republic of Kazakhstan)** | | | | |
| 1. | 050703 | FCD | Information Systems | AEER / EUR-ACE® | 2011-2016 |
| 2. | 050713 | FCD | Transport, Transport Facilities and Technology | AEER / EUR-ACE® | 2011-2016 |
| | **L.N. Gumilyov Eurasian National University (Astana, Republic of Kazakhstan)** | | | | |
| 1. | 050702 | FCD | Automation and Control | AEER / EUR-ACE® | 2011-2016 |
| 2. | 050732 | FCD | Standardization, Metrology and Certification | AEER / EUR-ACE® | 2011-2016 |
| 3. | 050901 | FCD | Organization of Transportation, Traffic and Operation | AEER / EUR-ACE® | 2011-2016 |
| 4. | 6N0702 | SCD | Automation and Control | AEER / EUR-ACE® | 2011-2016 |
| 5. | 6N0732 | SCD | Standardization, Metrology and Certification | AEER / EUR-ACE® | 2011-2016 |
| 6. | 6N0901 | SCD | Organization of Transportation, Traffic and Operation | AEER / EUR-ACE® | 2011-2016 |
| | **Innovative University of Eurasia (Pavlodar, Republic of Kazakhstan)** | | | | |
| 1. | 050701 | FCD | Biotechnology | AEER / EUR-ACE® | 2010-2015 |
| 2. | 050718 | FCD | Electrical Power Engineering | AEER / EUR-ACE® | 2010-2015 |
| | **Kazakh National Technical University named after K.I. Satpaev (Almaty, Republic of Kazakhstan)** | | | | |
| 1. | 050704 | FCD | Computer Science and Software | AEER / EUR-ACE® | 2010-2015 |
| 2. | 050711 | FCD | Geodesy and Cartography | AEER / EUR-ACE® | 2010-2015 |
| 3. | 050712 | FCD | Mechanical Engineering | AEER / EUR-ACE® | 2010-2015 |
| 4. | 050718 | FCD | Electrical Power Engineering | AEER / EUR-ACE® | 2010-2015 |
| 5. | 050723 | FCD | Technical Physics | AEER / EUR-ACE® | 2010-2013 |
| 6. | 050713 | FCD | Transport, Transport Facilities and Technology | AEER / EUR-ACE® | 2011-2016 |
| 7. | 050716 | FCD | Instrumentation Engineering | AEER / EUR-ACE® | 2011-2016 |
| 8. | 050719 | FCD | Radio Engineering, Electronics and Telecommunications | AEER / EUR-ACE® | 2011-2016 |
| 9. | 050720 | FCD | Chemical Technology of Inorganic Substances | AEER / EUR-ACE® | 2011-2016 |
| 10. | 050721 | FCD | Chemical Technology of Organic Substances | AEER / EUR-ACE® | 2011-2016 |
| 11. | 050722 | FCD | Printing | AEER / EUR-ACE® | 2011-2016 |
| 12. | 050724 | FCD | Processing Machinery and Equipment | AEER / EUR-ACE® | 2011-2016 |
| 13. | 050729 | FCD | Construction | AEER / EUR-ACE® | 2011-2016 |
| 14. | 050731 | FCD | Life Safety and Environmental Protection | AEER / EUR-ACE® | 2011-2016 |
| 15. | 050732 | FCD | Standardization, Metrology and Certification | AEER / EUR-ACE® | 2011-2016 |
| | **Karaganda State Technical University (Karaganda, Republic of Kazakhstan)** | | | | |
| 1. | 050702 | FCD | Automation and Control | AEER / EUR-ACE® | 2010-2015 |
| 2. | 050707 | FCD | Mining Engineering | AEER / EUR-ACE® | 2010-2015 |
| 3. | 050709 | FCD | Metallurgy | AEER / EUR-ACE® | 2010-2015 |
| 4. | 050712 | FCD | Mechanical Engineering | AEER / EUR-ACE® | 2010-2015 |
| 5. | 050713 | FCD | Transport, Transport Facilities and Technology | AEER / EUR-ACE® | 2010-2015 |
| | **Kostanay Engineering and Pedagogical University (Kostanay, Republic of Kazakhstan)** | | | | |
| 1. | 050713 | FCD | Transport, Transport Equipment and Technology | AEER / EUR-ACE® | 2011-2016 |
| 2. | 050732 | FCD | Standardization, Metrology and Certification | AEER / EUR-ACE® | 2011-2016 |
| | **Semey State University named after Shakarim(Semey, Republic of Kazakhstan)** | | | | |
| 1. | 050727 | FCD | Food Technology | AEER / EUR-ACE® | 2010-2015 |
| 2. | 050724 | FCD | Processing Machinery and Equipment | AEER / EUR-ACE® | 2010-2015 |

# Dear Colleagues!

Association for Engineering Education of Russia invites all universities to participate in the non-governmental-professional accreditation of engineering education programs. This non-governmental-professional accreditation in engineering and technology is a process to improve the quality of engineering education in accordance to the global standards, and to obtain acknowledgement in the professional engineering community for high-qualified professional engineering training.

Such accreditation of engineering education programs provides the opportunity to obtain an independent evaluation of the quality of the university's education programs and recommendations for their further improvement; to assert one's high-professional engineer training level and, thus, enhancing the competitiveness of engineer-graduates in the domestic and global labor market.



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- List honorary titles in the professional field (for example, Honorary worker of higher professional education of Russian Federation)
- Contact information: full address, telephone, fax, cell phone, e-mail

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