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Editorial board

DEAR READERS,

THE ISSUE OF JOURNAL "ENGINEERING EDUCATION" IN FRONT OF YOU IS DEDICATED TO THE EDUCATION QUALITY OF SPECIALISTS WITH HIGHER EDUCATION DEGREE IN THE FIELD OF ENGINEERING AND TECHNOLOGY WITHIN NEW-TYPE INDUSTRIALIZATION.

Technological modernization of Russia, the need for which was announced in many stump speeches, is impossible without highly skilled engineering staff. Today, engineering training in higher education institutions should be run taking into account current state-of-art characterized by a loss of Russia its advanced position in the world in many technical areas. Requirements to graduates from engineering educational programs must be substantially modified. University graduates in engineering are expected not only to have a range of professional competences, but also to be able to apply these competencies for real practice, be able to formulate and solve engineering problems. They are required understanding of business processes, ability to effectively use systematic approach for solving problems, ability to work as a team member and team leader, ability to take responsibility for decisions. They are required to be highly-motivated and competitive in their professional field.

Graduates of engineering programs especially need all these qualities within new-type industrialization, which essence was described by V. Putin in his article "We need a new economy"', when formulation and solution of engineering problems should lead to the development of new industries. Finding own "competitive niche" in the existing global markets, creating markets of new products, winning the global competition all these steps should lead to the development of new Russian brands and, ultimately, to the definition of Russia's place in the global division of labor.

After transition of Russian higher education system to a two-tier degree structure, Bachelors and Masters have become the basis of engineering staff. Academic staff of technical universities, teams of university managers, organizers of higher education at the regional and federal level concentrates their efforts to ensure students' training for real engineering practice.

Familiar to many Russian people system of training when graduate of a technical university or faculty was qualified "engineer" and in accordance with the job description and company schedule of positions and salaries, was enlisted as an engineer, moved to the past. One can be glad or regret it, but the reality is that, in accordance with the principles of the Bologna Declaration also signed by Russia, the fact of transition from university training with awarding qualification "engineer" to training with Bachelor and Master degrees took place. Graduating student who was awarded an engineering degree, of course, was not an engineer in the full sense of this term, but after a year or two, based on the acquired at university knowledge, gained experience and got the opportunity to apply his or her engineering skills. Approximately after five years many of them became real engineers.

The System of Certification of engineering qualifications that exists for a dozen of years in many countries, in fact, resembles the above described system of becoming engineer in Russia. The only difference is that engineers in these countries after graduating from university continued working in their professional field and demonstrated their ability to solve real engineering problems. And in our case, an engineering degree just permitted to get certain engineering positions or any position in general that needed higher education degree, but did not require solving engineering problems. Many of them were able to retain qualified engineers for the whole their life without real engineering practice for a single day, however being enlisted in the engineering staff of the country.

We used to think that Russian engineers were among the best in the world. And now, in the context of globalization and competitive environment, our educational system has to prove that the quality of Russian bachelors and masters will help to form engineering staff of the country able to provide Russia a leading position in the world in the field of engineering and technology.

Study of employers opinion in the level of training in the field of engineering and technology shows that the quality of graduates training often does not meet their requirements.

In particular, the list of disadvantages of engineering learning outcomes includes the following: lack of necessary teamwork skills, lack of key business process awareness and ignorance of the Russian business environment in general, inability to apply systematic approach, extremely low efficiency and performance of engineering work.

Graduates of engineering programs lack knowledge and skills in the use of high-performance integrated computer network design (CALS-technologies). They do not know the methods of nonlinear physics and nonlinear dynamics of complex systems (synergy), fractal concepts.

They often lack skills in business communication and negotiation, presentation and language skills are poor developed. Young specialists lack professional skills, knowledge of laws and methods of Theory of Inventive Problem Solving, motivation, focus on professional development and career advancement, ability to present themselves and the results of their work in professional sphere.

At the same time, employers note overestimated requirements and ambitions of graduates that do not match the level of their training, the failure to adequately assess their value in the labor market.

It is important to make review and analysis of engineering educational programs content and educational technologies regarding graduates' disadvantages listed by employers when planning and carrying out work to improve the training of specialists in the field of engineering and technology. At least today, this analysis shows that universities do not teach future engineers in accordance with employers' expectations within new-type industrialization.

Quality Assurance of Engineering Education suggests close cooperation of universities with leading companies and research institutions. This cooperation is required at all stages of training, including the design of educational programs using a competency approach, the organization of problem-based and project-organized learning process, block-module curriculum, providing a large amount of independent students' work to solve real industrial problems, graduates' career support .

In this issue of the journal "Engineering Education" the authors of the published articles share their views on how to improve the training of future engineers at universities within new-type industrialization.

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

Contents

National doctrine design principles in Russian engineering education within new-type industrialization: problems, objectives, challenges

National Research Tomsk Polytechnic University
Y.P. Pokholkov, B. L. Agranovich

The authors analyze contemporary conditions of Russian engineering education and propose principles and strategies to improve Russian engineering education according to modern requirements.

Key words: *sengineering education, national doctrine, new-type industrialization, new education technologies.*

Y.P. Pokholkov

B. L. Agranovich

The state of engineering in any country is closely connected with the state of engineering education and the level of training in the field of engineering and technology. And Russia is not an exception. The survey conducted by the Association for Engineering Education of Russia (AEER) in 2011-2012 shows that engineering in Russia is in a critical condition [1, 2]. Main characteristics of this condition are quite obvious: - replacement of domestic consumer goods, facilities, technologies and equipment by imported ones, loss of competitive position in the world markets of engineering products, lack of outstanding engineering solutions within the last 20-25 years, low share of machinery, equipment and technology in the structure of Russian export (3.5%). Decrease of the training quality in the field of engineering and technology is not the only reason that led to this situation. The reasons have a systematic character and are connected with politics, economics, management and social sphere. However, one must admit that the crisis in engineering points to the crisis in the state of engineering education in the country.

Analysis of world markets of engineering products shows that Russia is irrevocably behind the world leaders in many areas of engineering and technology. Invalid attempts to catch up with or even pass them and let them ahead in competition can only lead to ruinous race for our country. In these circumstances, the most appropriate is the way of new-type industrialization, which features were outlined in Vladimir Putin's pre-election article "We need a new economy" [3].

The core idea is to find directions of industrial development (niches), where breakthrough efforts for new results and development of Russian brands are possible. In fact this will determine Russia's place in the international division of labor and can become the basis for the long term development of national doctrine of engineering education.

However, today there is no strategic program of new industrialization with structurally defined objectives and system indicators, means of achieving the objectives, organizational structure of the industrialization of the country, sources of financial, human, structural and other resources, road map and regional industrialization, a policy to heighten interest in industrialization of all participants. Only availability of such a document will permit to develop an effective doctrine of engineering education within new-type industrialization, providing target advanced training and massive retraining to address the new industrialization. Therefore, legislative and executive bodies of federal and regional level together with expert community should work out these documents [4], using modern methods of system and process design, project management, "foresight", etc., effective methods of expert information processing, information and telecommunication technologies.

In accordance with all stated above today it is impossible to develop efficient doctrine of engineering education within new-type industrialization. At the moment it makes sense only to discuss the principles and approaches for the development of the doctrine of engineering education within new-type industrialization. And this article is dedicated particularly to these points.

The National Doctrine of engineering education, based on the above mentioned documents should allow to formulate objectives for development and improvement of engineering education in the midterm, and to identify a list of urgent tasks to enhance engineering education in Russia.

The systemic nature of the crisis in the state of engineering and engineering requires systemic, political and economic decisions, covering preschool, general and higher professional education, changes in the statutory framework, regulating the relationship between business, scientific and academic community and governing bodies. At the same time representatives of professional (expert) community should formulate the policies pursued in these areas on the basis of a systemic approach in clear and understandable terms agreed in the related fields, providing a balance between the interests of individuals, society and the state.

Nowadays the National Doctrine of engineering education should focus on advanced training and retraining of specialists able of achieve the objectives, solve the problems of the new-type industrialization. The National Doctrine of engineering education should be approved by the Federal Law after extensive public discussion and expert consultation.

To meet the challenges of new-type industrialization the training should be focused on other areas than traditional training in engineering and technology, which are significant for the successful industrialization: production engineer, industrial engineer, service engineer, etc.

Production engineer is responsible for interaction of his unit with the heads of other departments, technologists, rate-setting engineers, engineers, mechanical engineers, etc., takes measures to improve the quality, productivity, etc. and focused on the complex process improvement of his plant efficiency.

Industrial engineer – an organizer, an ideologist of the production [5,6]. He applies modern methods of industrial engineering, interdisciplinary approach, technological forecasting, system analysis, new management tools. He studies domestic and foreign markets and is ready to complete optimization of all processes in the enterprise, to forecast market behavior and participates in their development in the interests of the company and customers.

Service engineer is responsible for installation, commissioning, adjustment setting and system testing of new equipment and technological process to ensure a given product quality, capacity and other characteristics. In addition, service engineer conducts regulated testing during the equipment and technology life cycle: primary, planned and unplanned, and also organizes innovative and inventive work aimed at improving the installed equipment and technology.

The outlined objectives of advanced training require substantial modernization of content, educational technologies and organization of engineering education.

Present-day higher education institutions that are training specialists in engineering and technology will be able to cope with the task of preparing the required personnel if they actively join all the above mentioned processes and receive substantial support from the state and private investors to upgrade their facilities. Moreover a certain part of specialists could be trained at foreign universities.

Massive retraining and skills development could cause more urgent problem. Its solution can be found in the development of Smart education in the country using domestic and foreign educational resources.

Way to achieve the outlined goals

Achieving these goals requires restructuring of engineering education content, transition to new educational technologies and new organizational structure of the training process.

Principles of engineering education content development

Study of the requirements to engineering within new-type industrialization allows to develop principles of engineering education content [6].

The content of engineering education should include the following fractal organized totality:

- teaching, which provides mastering of the humanitarian, social and economic, mathematical and natural-scientific, general and vocational knowledge on the required level;
- education, which provides development of the methodological culture of the graduate; mastering of the methods and techniques of the cognitive and professional, communicational and axiological activities;
- ability performance, which provides a complex training of the student for professional activities and his/her professional self-actualization.

To turn a student into a professional engineer, it is important that he change the sphere of education for the sphere of activities. It is important to integrate knowledge and methods of functioning, where the key values are its system-forming factor. To increase a student's professional potential, it is important to leave the sphere of knowledge for the sphere of practical activities and problem solving.

The distinguishing feature of the system of knowledge for training engineers is the stability of natural scientific, mathematical and world outlook basis of knowledge, the broadness of the interdisciplinary system-integrated knowledge of nature, society, way of thinking, and also a high level of general professional and special professional competence, that provide functioning in the problematic situations and allow to solve the task of specialists training with greater creativity.

Not only subjects should become the basis of education, but also the ways of thinking and functioning, i.e. procedures of reflective nature. Knowledge and methods of learning and functioning should be united into organic integrity. All this poses a task of including the issues of developing methodological culture, including methods of cognitive, vocational, communicational and axiological activities into the requirements to content and level of engineering training.

The distinguishing feature of the engineering education should become a high level of methodological culture, superb creative mastering of the methods of cognition and functioning.

As experience of specialists training shows, the successful activities of the engineers are determined not only by the high level of knowledge, productive mastering of the methods of cognition and functioning, but also by the complex training for professional work. It is determined not only by the training for professional work in the conditions of the normal life and established production, but also for the tests, changes in the ways of life, for the repeating changes of their world-outlook, ideologies and concepts. Thus, successful vocational activity suggests not only a high level of teaching and education but also spiritual, moral, social, psychological, and physical culture of any individual. The University should become not only the center for science and education but also the center for ability development of a person, his professional coming-into-being and self-actualization.

When designing the content of education and the requirements to the level of training engineers, it is important to find the place for the system of knowledge and methods, aimed at accomplishing the tasks of self-knowledge and self-actualization of an individual.

Vital role in the development of engineering education content plays its humanitarian, fundamental and professional orientation.

Valuable and semantic nature of humanitarisation of engineering education appears in providing of harmonic unity of natural and scientific and humanitarian standard of knowledge and activity, unity based on mutual understanding and dialogue.

The most crucial task of the system of engineering education in this respect is to create conditions of revival of unified natural and scientific and humanitarian standard of knowledge and activity.

Development of the engineering education content includes the following points:

- fundamental nature of scientific knowledge in engineering education and engineering activities;
- ensure the development of professional innovative thinking;
- complex training for innovative activities (ability performance).

An important role in the content of engineering training plays fundamentalization of engineering knowledge and engineering in engineering:

- development of fundamental laws of design and development of artificial environment: synergy, TRIZ, CALS-technologies;
- increasing of interdisciplinary knowledge that provide innovation in problem situations;
- development of methodological culture: professional, cognitive, communicative and axiological activities;
- learning of natural science and humanities, transition on this basis to complex criteria: capacity, efficiency and quality of the designed artificial environment.

One of the important tasks of engineering training within new-type industrialization is the development of innovative thinking [7].

Innovative thinking is an integrated set of creative, strategic, systemic and transformational thinking activity based on the laws of interdisciplinary knowledge:

- creative thinking: interdisciplinary knowledge, theory of the development of engineering solutions, multicriteria formulation and solution of innovation problems, heuristics;
- strategic thinking: strategic management, synergy and the theory of self-organization;
- systemic thinking: systemic approach, system model, morphological analysis, systemic genetic analysis, systemic functional analysis;
- transformational thinking: self-management, CALS-technologies, organizational culture.

Another necessary element should be a complex training for innovative activities:

- development of scientific principles and methods of innovation, technology transfer;
- mastery of knowledge and the development of marketing and modern management methods, business ethics and laws;
- studying of foreign languages at the level providing professional

work in a foreign language environment.

Transition to new educational technologies in the engineering education

The essential point in engineers' training is to use active and productive methods of global information resources for learning, methods of forming cognitive and professional activity, development of personal qualities:

- benchmarking, case studies, personal & professional development training, business training;
- organizational and business activity-games;
- problem-and project-based learning;
- creative workshops;
- design sessions;
- interdisciplinary projects;
- projects on the real customers' needs.

The major direction of engineering education development in this respect is the special organization of student's work throughout the period of study at university in complex multidisciplinary practice-biased teams, students' involvement into a creative activity, maintenance of their mass participation in research, creation of purpose-biased education.

All these should create favorable preconditions of evolutionary transition in the engineering education from the educational ("the school of memory") to the research and educational processes.

Nowadays, the educational process can be presented as the system of workshops led by creative, skilled and prominent researchers and leading engineers. The updated community of students, competitors for bachelor's and master's degree and engineering status, post-graduate students and people working for a doctoral degree form creative teams, a kind of scientific school capable of maintaining the continuity of cognitive activity, awareness of the world and the individual's place in it, ideals, values and objectives of the scientific and engineering work.

Modern education technologies in the system of engineering education embrace widespread academic mobility.

Today all-sufficiency of the university in any country, which is aimed at professional training of engineers competitive on the world market of intellectual labor, has been exposed to fair criticism. The need for academic mobility, training at some Russian and foreign universities and active involvement of industry representatives in the training process is considered crucial for changing the qualitative status of specialist's training.

Keeping the quality of engineering education at the level demanded by the society

The doctrine shall include an integral system aimed at keeping the quality of engineering education at the socially adequate level. The following system components should be included:

- the new generation of national educational standards and individual universities' standards set on the basis of the former;
- system of public and state attestation of engineering educational institutions;
- system and technology of accreditation of vocational educational programs in different academic fields performed by both domestic and foreign public vocational associations along with national specialized agencies;
- system of engineering specialists certification and awarding of engineering certificates of all the levels (e.g. European instructor, engineer);
- system of social and economic stimuli aimed at professional promotion and elevation of the public status of an engineer;
- system of continuous advanced training and postgraduate engineering education.

Conclusion

To conclude, it is crucial once again to emphasize the importance and necessity of the national engineering education doctrine as it is the document, which accurately reflects the views of the scientific community, society, individual and state on the future of the Russian engineering education.

The National Doctrine of the engineering education should serve as a basis for Federal Program for Vocational Education Development while legislative acts and government decrees should correspond to its provisions. It should provide sources for professional engineering ethics development and for all the decisions taken by public associations and other organizations.

The National Doctrine of the engineering education can only become efficient if all the necessary mechanisms are established and its continuous application, actualization and enhancement in response to the changing conditions, factors, and new engineering requirements are provided.

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Systems engineering – an important component of modern engineering education

All-Russian Scientific and Research Institute for Nuclear Power Plant Operation
G.V. Arkadov
Moscow State Technical University of Radioengineering, Electronics and Automation
V.K. Batovrin, A.S. Sigov

The article discusses the necessity to introduce systems engineering into engineering education programs. It characterizes the systems engineering methodology, states the necessity of systems engineering education. The paper deals with the problems of systems engineering education management and the requirements to the education programs in this field. It proves that systems engineering training is one of the key ways to the formation of new generation of engineers who can create competitive systems for the world market.

Key words: *systems engineering, engineering education, competitive system, educational programs.*

G.V. Arkadov

V.K. Batovrin

A.S. Sigov

Introduction

Russian high-tech enterprises feel shortage of engineers who can make competitive products and services. As a result, big companies of nuclear, energy, space, military (defense) and other branches have to influence on the educational market asking for implementation of the world level education programs on the one hand. On the other hand, they have to invite more and more foreign specialists, that takes a lot of resources.

The crisis phenomena are increasing at a time when most of Russian technical universities are not ready for production of graduates who are capable of free and creative engineering work in the market economy. These conditions make the engineers use not only the basic fundamental knowledge but also put and solve the tasks of science and technical development [1].

On the other hand, the problems in the sphere of engineering training are being exacerbated because of objective changes going on in the environment, such as:

- unprecedented complicacy of the basic engineering product – systems;
- fast emergence and development of new technologies with simultaneous necessity to prolong (sometimes more than once) a life cycle of the systems having been put into operation;
- constantly increasing competition on the market of engineering products and services;
- rapid complicacy of engineering activity both its management and implementation components.

The abilities needed for creators of complex modern systems are formed and developed at the student stage. That is why it is possible to reach the main goal – the formation of an engineer capable of making systems competitive in the world market - at the stage of basic university training. In these conditions Russian technical universities are required high professional level, constant education programs improvement, and creative use of foreign colleges' achievement taking into account Russian realities on the educational service market.

The analytical report [2], made by a group of famous Russian specialists, states that the ideology basis of Russian vocational education is the idea of what the specialist should be, what the training technique is and how to make a specialist of a certain quality. But there is no idea about the specialty. The analysis shows that while the number of specialties is growing and the requirements to the specialists are increasing the career success doesn't depend on the specialty written in a diploma. The authors of the above mentioned report make a reasonable conclusion that Russian Higher Education's Doctrine is doubtful so far as relevant to the content and management of educational process and student training as the higher educational establishment can give knowledge and competencies to the graduate, but the graduate can become a real specialist only after acquiring some practical professional experience.

In spite of more than 20 years of stagnation in the sphere of complex systems and new technology development, our specialists are still able to develop high-tech systems and to support their full life cycle (LC). But on the whole, the competitiveness of the systems made by Russian specialists in recent years is constantly decreasing. In authors' opinion, such situation is basically the result of the following: Russian enterprises and Higher Engineering School underestimate the key role of systems engineering in ensuring competitiveness of Russian engineering systems. It is systems engineering and it's most important components such as program engineering, requirement engineering, changes management, architectural design that make the basis for a sustainable construction to support the connection between mission, strategic goals, aims and measurable results of engineering activity.

In light of this, a special role of education in the sphere of systems engineering becomes obvious. It is important for training engineers in different fields: mechanics, radio engineers, nuclear engineers, aviation engineers, bioengineers, program engineers and other specialists working on systems and their elements. The thing is that the basic task for systems engineering is to give a method and an instrument to the interested parts to create effective systems of different classes that meet the people's needs. To solve this task, the systems engineering, being developed as a complex approach, is focused on the core of engineering activity. It studies its key aspects in their interaction. Thus, the systems engineering, if included into education programs of engineering training, can become the basis to form a new body of engineering training programs for different spheres. It can be the foundation that makes possible to create a complex of competences necessary for graduates to be successfully adjusted to various professional engineering practices.

Systems engineering methodology

Systems engineering as a new applied system methodology appeared in the middle of the 20th century as a response to sharp complicacy of scientific, technical and management problems, on the one hand, and to the growth of responsibility for the results of these activities, on the other hand [3, 4]. Nowadays the international scientific and industrial communities recognize the systems engineering as a methodological basis to create systems of any classes and purposes. There are several directions where the systems engineering puts most efforts. They are the performance management to develop systems; staff training; standardization, development and support of systems engineering and some other [5].

In foreign scientific and methodical works the systems engineering is formulated as interdisciplinary approach and methods determining a full set of technical and management efforts to transform needs of a customer and other interested parts, expectations and limits into a system solution and to support it during its life time [6].

It was A. Hall who first described the systems engineering methodology more than 40 years ago [4]. He determined it as an organized creative technology and characterized the following statements as the basic ones.

Firstly – the systems engineering is multidimensional and this fact is to be surely reflected while determining its subject.

Secondly – the systems engineer should be aware that the goal of the whole systems engineering process is to make optimal boundaries between human's interests, the system and its environment. The environment consists of three components:

- physical and technical environment
- business and marketing environment
- social environment.

Thirdly – the systems engineering studies first of all needs. This study should be based on the advanced economic theories, market demands and the possibility to change these demands now and in the future as well.

Another important feature of the systems engineering is its close interaction with systems thinking. Actually, the main idea of systems thinking is to detect, observe and realize complex emergent behavior resulting from dynamic systems interaction in working process. But the ability to act using systems' language, which is so important for an engineer, is not described in the works devoted to the systems thinking. It is exactly this point, as H. Lowson underlines [7], where the systems engineering adds to the systems thinking. This feature of the systems engineering proves the importance to study it for a modern engineer's world outlook.

Thus, from the very beginning of the systems engineering development and up to now the basis of engineering activity is considered to be system complex and joint use of technical, economic, management and other disciplines' achievements. It is this approach that gives special relevance to the systems engineering and makes it possible to use its achievements to build developing systems of different nature and purpose. This approach distinguish (but not oppose) the systems engineering from other more familiar for Russian specialists subjects such as quality management, project management, supply chain management, resource management, risk management and other.

The core of the subject "systems engineering" is underlined by many specialists: the systems engineering is focused to solve both management and design problems within the framework of full LC management. A.P. Sage, a leading authority, points out that the systems engineering is the management technology focused on control of full LC processes to choose, develop and apply the most effective, reliable and quality systems to meet customers' demands [8].

LC is understood as the development process of a system, product, service or other human made object form its idea and concept up to its retirement. Taking it into account the systems engineering regards the LC management goal as the organization being able to choose and implement effective LC processes on a solid methodical basis. As a result, the system of the parts' interest can develop during its LC and satisfy the statutory requirements.

That is why systems engineering became the key compulsory subject for the future or present day engineers working for global engineering corporations as well as for the leading technical universities of the world.

Necessity of systems engineering education

For the last 10-15 years a set of theoretical and practical recommendations on complex systems development has been created and tested by international systems engineering associations. The formation of integrated international system of standards and the best practices is about to be finished. The practices contain the regulations and instructions to be used while developing a system and managing its LC. There are a lot of international corporations and organizations working on that problem. IEEE, INCOSE, Boeing Company, NASA, General Dynamics, BAE Systems and others are among them. The result of their activity is the formation of new cultural environment for developing a system of any class and purpose. The absolute majority of the successful companies, that develop competitive systems work in that environment. That process is taking place before our very eyes.

We can only bitterly state that our country hasn't taken practical part in formation of the environment. Besides, there are no specialists ready to use the systems engineering regulations and instructions while developing a system and managing its LC. Unfortunately no university trains such staff with the purpose to meet the demands of industry and society. Taking into account the mentioned above the necessity to establish systems engineering education both in the frame of Master and Bachelor degrees as well as in the frame of additional education becomes obvious.

The fact should be noticed that nowadays all over the world the companies dealing with the complex system development feel the shortage of high qualified engineers. A lot of foreign experts including employers and higher school representatives declare the engineering education crisis which is conditioned by a number of factors. One of the factors is the fact that engineer's position doesn't bring any advantage. In particular, engineers are required high professional competencies but are low paid in comparison with lawyers, bank employees and government officials. Foreign colleges think that in these conditions high level of systems engineering education can not only contribute to the formation of common cultural engineering space but also encourage the young to choose engineering activities.

The interest of foreign scientific and educational community to systems engineering is proved by the facts that 50 manuals and textbooks on this topic have been published for the last 3 years and the subject of systems engineering and its sections are included in curricula of about 500 universities [9]. Teaching materials in systems engineering and its sections are widely presented in educational networks. MIT OpenCourseWare (http://ocw.mit.edu/index.htm) a site of Massachusetts Institute of Technology is an example. Finally, the biggest government agencies and the leading international enterprises are developing their own regulations in systems engineering [10, 11] and training their staff in this sphere [12, 13].

While discussing the problems of Russian engineering education reform we should determine the urgency to solve the problems of systems engineering as one of the key tasks. With systems engineering as a base it is possible for Russian Universities to train specialists who will be able to set goals and tasks, develop and manage competitive systems.

Who should organize (manage) systems engineering education?

To answer that question it is necessary to describe the domestic engineering environment. We should remind that the target training of systems engineers in our country was established quite long ago: systems engineering department was organized in Moscow Power Engineering Institute in 1969. Similar departments were gradually established in many technical higher schools all over the country and with the support of domestic industry in the mid 80s its number reached 30. Thus, the USSR industry jointly with higher education establishments made the conditions for training of systems engineers in quantity sufficient for the country. But the quantity didn't turn into quality. The domestic systems engineers were not the specialists to develop competitive systems; they couldn't formulate and define the scope of work to create a complex system, ensure the maintenance and management of its LC and use creatively technological, management and economical achievements in their work. Our engineer was trained primarily as a technical specialist who can solve the problems of development and functioning of automated process control systems and know how to make separate system elements.

There were a lot of factors conditioning such situation but we will mention only one: the original term "System engineering" being translated was substituted into "systemotekhnika", which was understood primarily as a technical term referring only to techniques and technology. The core of systems engineering as a cross discipline approach and methodic turned out to be lost to a large degree. During its infancy the USSR systems engineering didn't manage to integrate into the global systems engineering environment, which hindered its development. The events of the 80s and 90s put an end to it at all.

In addition to objective difficulties of engineering education and activities there is one more problem in our country: for the last 20 years we have lost a whole generation of system developing specialists on the one hand and the generation of instructors who could train engineers on modern basis on the other hand. This "lost generation" has no experience in big system development. The connection with real information holders in this sphere has been broken. This generation hasn't got basic fundamental training that can meet the demand of global modern technical development. Significant part of this generation even has no idea about the achievements of the world science and systems engineering. The language barrier adds to this problem: statistics show that most domestic specialists and graduates of the leading technical universities are not ready to work in English-speaking professional environment.

Russian engineering School and employers are disunited. It is quite common nowadays when large companies actually retrain their young engineers or hire foreign specialists. They consider it impractical to collaborate with higher school on a constant basis. Besides, experienced and high qualified specialists trained in the USSR are not psychologically ready to perceive modern foreign achievements because traditional engineering culture, inherited by us, and contemporary western engineering culture differ from each other greatly.

To overcome cultural differences is one of the key problems as we can keep and possibly develop our scientific potential in the sphere of competitive systems engineering only by integrating into the world engineering community. We should note that to overcome the cultural differences and the backlog the efforts only of higher School are not enough. The domestic industry should play an important part in it. It should take its place on the global market and form a clear image of what the national educational politics should be to have engineers able to create competitive systems.

Thus, great infrastructural shifts in domestic engineering environment are necessary to organize systems engineering education. Actually it is necessary to answer if our educational system is ready to become a part of the world educational system and if our domestic Higher School will be able to overcome the crisis of training of engineers who can make competitive products and services. On the other hand, our Higher School hasn't been answered yet if the domestic industry and business feel the shortage of such engineers or our country needs engineers to maintain foreign equipment and high qualified specialists are better to be trained abroad.

We should note that the collaboration of western universities with hi-tech producers is at a high level. For example, Massachusetts Institute of Technology, which is the leader of systems engineering education, collaborates with more than 20 world's largest companies in implementation of such educational programs. Among these companies there are Amazon.com, Inc; Boeing Company; Dell; Harley-Davidson; General Dynamics; General Motors; Honeywell; Intel; Nokia; Northrop Grumman; Novartis AG; Raytheon and this impressive list can be continued.

The problem solving in engineering education, in particular, systems engineering, is a common task both for domestic industry and higher school. The main problem, which is to ensure the possibility of stable development of solid domestic engineering environment for competitive complex system production, can be solved only by focused and concerted actions of all the interested parts. Systems engineering will only be a matter of enthusiasts unless higher institutions and the industry agree about engineers' training, unless the domestic industry integrates into the global engineering environment and offers the graduates decent working conditions, unless the engineering universities are aware of necessity to integrate into the world engineering education environment.

The reason for optimism is that the universities and the industry have started solving this problem.

In the end of 2010 the Department of Strategic Planning and Management Methodology was established in National Research Nuclear University MEPHI at the faculty of Physics and Economics of high technologies. The main aims of the department are to train engineers, architects and designers of LC of complex technological objects.

Some years ago a non-commercial organization - Russian Institute of Systems Engineering (RISE) - was established by a number of leading Moscow technical universities in close cooperation with the International Council on Systems Engineering (INCOSE). Its aim is the development of systems engineering in Russia.

In 2008-2011 a series of lectures, seminars and conferences conducted by the world leading specialists in systems engineering, LC management and data integration was held with a joint participation of RISE and All-Russian Research Institute for Nuclear Power Plant. Those events interested the engineering community very much and encouraged the launching of several innovative projects in the nuclear sector.

Approaches to education management in systems engineering

Foreign experience shows that it takes 6-8 years to train a component design engineer. And it takes 10-15 years to train a systems engineer who can develop system-wide solutions and do system integration.

To get a high professional level a systems engineer should have work experience in a world leading company of a particular direction. Thus, it is obvious that systems engineering training should take place on all educational level from bachelor degree up to the system of engineering further education.

While organizing systems engineering education it is useful to take into account foreign experience that shows that the first efforts should be focused on the following:

- to consolidate professional and academic societies that are interested in overcoming the crisis of engineering education in our country.
- to analyze and introduce advanced foreign experience in management of systems engineering education and systems engineer training.
- to choose pilot training lines to test the developed syllabi.
- to accelerate the formation of reference methodical and training materials in systems engineering available in Internet. The results of project BKCASE (Body of Knowledge and Curriculum to Advance Systems Engineering) can be taken as a basis. The project aims to form a set of knowledge and curriculum to advance systems engineering [14]. It is powered by Institute of Electrical and Electronics Engineers, IEEE, International Council in System Engineering, INCOSE, Association for Computing Machinery, ACM and many other world famous academic and professional organizations.
- to train instructors (teachers) in systems engineering and related subjects in leading foreign universities with the help of Russian industry and professional organizations.
- to translate into Russian a set of the best foreign textbooks and books for systems engineering like it was done in the USSR in the 60's of the last century on the initiative of Professor Povarov G.N.

The problems of academic and professional communities' consolidation were mentioned above.

While studying foreign experience of educational program management we notice two problems stated by our colleges: the choice of key competences required from a system design-engineer and the formation of basic requirements to the content of educational programs. The example is the work of 15 employees of National Space Agency of the USA that have all together 390 years of collective experience (almost 4 centuries) in systems engineering in aerospace section [15].

These specialists distinguish 11 basic personal qualities for a good systems engineer to have:

1. Intellectual curiosity which is expressed through the willingness and ability to constant learning of new.

2. The ability to see the whole even if there are a lot of small details. In particular, the ability to keep in mind the main goal and to unite scientists, designers, operators and other interested parts for effective collaboration regardless the changes appearing during the LC.

3. The ability to distinguish the system-wide connections and regularities, which makes the system engineer being able to help other team members to put their system solutions in the whole system to get the system's goals.

4. High sociability. That is the ability to listen, to write and to speak in the manner that helps (promotes) effective communication between engineers and managers on the basis of common terms, processes and procedures.

5. The ability to work both as a leader and as a team member, which implies deep interdisciplinary knowledge, being target driven, creativity and engineering instinct.

6. Readiness for changes including the awareness of their inevitability.

7. Suitability to work in conditions of uncertainty and lack of information, which implies the ability to interpret contradictory and incomplete requirements.

8. Conviction that you should hope for the best but plan to worst, which means that a systems engineer always check and check again the details referring to the system technical integrity.

9. Different technical skills - the ability to use reasonable technical solutions, which requires expert interdisciplinary knowledge.

10. Self-confidence and determination but not arrogance as any system engineer can make a mistake.

11. The ability to follow the instruction up to the moment when it is necessary

to change it, which implies engineering instinct.

On the other hand, there are more detailed descriptions of the requirements for system engineers [16]:

1. The ability to manage the requirements on all the levels of system's hierarchy.

2. The ability to use advanced methods and instruments of system development including architecture approach.

3. The ability to use methods and instruments of system analysis including modeling, reliability analysis, risk analysis, analysis of the technical and economic characteristics etc.

4. The ability to organize and conduct system's test and to analyze test data.

5. The ability to organize human-machine interaction.

6. The ability to implement integrated system solutions taking into account heterogeneity and the possible distribution of system elements.

7. The skill to implement the process approach.

8. The skill to manage changes.

Considering the issue we can analyze the basic standards of systems and program engineering [17, 18], the international organizations' recommendations [6] and the author's recommendations (for example [7]). It is also possible to give general characteristics of the typical profile of a systems engineer's activity and that of a contemporary engineering specialist (Fig. 1).

As shown in Figure, the systems engineer's basic efforts are focused on technical and design activities and besides design activity includes both works on system project management and works on configuration and risk management, taking decisions, measurements etc. On the other hand, in the process of system developing one thirds of systems engineer's efforts are spent on management and agreement activities. Typical processes that a systems engineer has to deal with at different LC stages are shown in Table 1.

It is interesting to compare the profiles mentioned above with some competences the engineering graduates (bachelors, masters and specialists) should have according to SES 3 (Table 2). These data need to be specially and deeply analyzed but even at the preliminary examination it is obvious that there is no system in the formation of competence profiles for engineering bachelors and masters. The same fact is true for the engineering specialists trained in accordance with SES 3.

The idea is that while choosing pilot directions it is necessary to start with establishing effective retraining and further training system for systems engineering stuff. This process should start with training of professional teachers (instructors) in systems engineering. Taking into account the immensity and multidimensionality of the problem it can't be expected to be solved in the near future at the state level. Apparently, to solve the problem one should rely on help of corporations that are interested in producing competitive complex systems to take a share of the world market. The experience of Public Corporation "Rosatom" might be interesting in this aspect. Since 2008 its enterprises have been implementing the recommendation of basic international standards of LC systems management ISO/IEC 15288 and informational support of LC ISO 15926 in their engineering activities.

While forming reference training materials in systems engineering available in Internet it is necessary to consider systems engineering and the related subjects as the basic ones for implementing the curriculum for designers of complex systems. Besides, we think that the Russian Association for Engineering Education and the Association of Technical Universities of Russia could support the prompt publication of BKCASE project's methodical materials in the Russian language and its further discussion by academic public of engineering universities of the country.

As for the retraining of domestic instructors and publishing of the best foreign books in systems engineering in Russian, this work has been started by RISE.

Lastly, it is necessary to note that while developing the systems engineering curriculum and the curricula of the related subjects it is necessary to look to the integration of Russian Higher School into the world community of system designers, to fast acquisition of the world scientific and engineering achievements and to effective adaptation of foreign programs and methods to our conditions. Above all, this topic needs to be studied and considered in details in academic, university and trade journals due to its big value and volume.

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Fig. 1 Approximate activity profile of a system engineer (a) and contemporary engineering specialist (b)

Fig. 1 a)

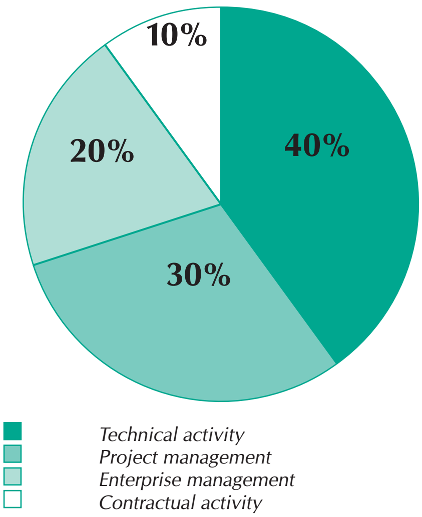
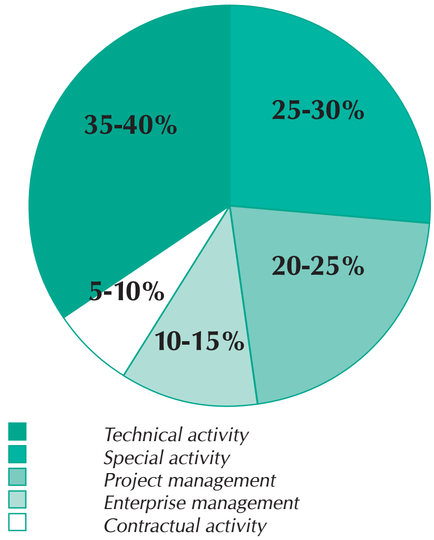


Fig. 1b)



Conclusion

The lack of attention to the organization and practical realization of system engineering education, the problem of "lost generation" of system designers, the need to take into account cultural differences between the rapidly developing western school and aging domestic school of system developments are a great challenge for our higher engineering school.

To find the way out of the situation it is necessary to integrate deeply the Russian engineering higher school into the world community of systems designers, to master the world practical and scientific achievements in systems engineering and to include systems engineering and the related subjects into the bachelor's, specialist's and master's engineering curricula. We should also purposefully adopt the extant domestic methods and traditions of complex system development to the system development methodology acknowledged by the international community.

The system movement becomes of high importance. It unites all the interested

Table 1
Systems Engineering standard covering processes and life cycle stages according to ISO/IEC 15288

Project-enabling processes	Project processes	Technical Processes
LC model management Infrastructure management Project portfolio management Human resource management Quality management **Agreement processes** Acquisition Supply	Project planning Project assess and control Decision management Risk management Configuration management Information management Measurement	1. Stakeholder Requirements Definition Process 2. Requirements Analysis Process 3. Architectural Design Process 4. Implementation Process 5. Integration Process 6. Verification Process 7. Transition Process 8. Validation Process 9. Operation Process 10. Maintenance Process 11. Disposal Process

parts such as teachers, specialists, students and post-graduates and can significantly contribute to the formation and possible development of modern educational environment which is suitable for systems engineers training and retraining in our country. It becomes more important taking into account the fact that we will hardly have this formation driven from top-down.

We think that the training in systems engineering is an important tool for creating new generation of engineers who are ready to produce competitive systems. It is a tool suitable for answering the challenges and for solving a number of problems facing engineering education and Russian engineering nowadays.

Table 2

Training direction	professional competences (types of activities) according to Russian SES 3								
	total	general	research	management	design	service and operation	installation and adjustment	industry and technology	other
	Bachelor (Master) degree								
140400 Electricity and Electrical Engineering	51 (32)	7 (9)	8 (3)	10 (7)	10 (6)	4 (0)	2 (0)	10 (6)	0 (1) (pedagogical)
140700 Nuclear Power and Thermal Physics	19 (28)	7 (9)	3 (5)	3 (6)	3 (4)	0 (0)	3 (0)	0 (0)	0 (4) (pedagogical)
141100 Power engineering	24 (22)	7 (9)	2 (4)	3 (2)	6 (4)	4 (united) (1)		2 (1)	1 (0) (pedagogical)
150700 Mechanical Engineering	26 (26)	0 (0)	4 (4)	8 (13)	6 (4)	0 (0)	0 (0)	8 (5)	0 (0)
160100 Aircraft	21 (23)	0 (0)	0 (7)	4 (7)	11 (5)	0 (0)	0 (0)	6 (0)	0 (4) (design and technology)
180100 Shipbuilding	19 (29)	0 (0)	4 (7)	5 (9)	3 (4)	2 (5) (technical and operational)	0 (0)	5 (4)	0 (0)
200100 Instrumentation	33 (31)	8 (6)	6 (6)	6 (6)	6 (8)	0 (0)	0 (0)	7 (5)	0 (0)
210400 Radio Engineering	32 (27)	7 (6)	5 (5)	4 (5)	5 (4)	4 (0)	2 (0)	5 (0)	1 (5) 0 (2) (design and technology, science and pedagogical)
220100 Systems Analyses and Management	13 (13)	7 (6)	2 (1)	0 (0)	4 (3)	0 (0)	0 (0)	0 (0)	2 (2) 0 (1) (science and pedagogical, design and technology)
231000 Program Engineering	27 (17)	0 (0)	5 (3)	4 (3)	6 (3)	2 (1)	0 (0)	2 (1) (technological), 3 (1) (industry)	3 (2) (аналитическая), 2 (3) (pedagogical)
the average bachelor (master)	26 (26)	4 (4)	3 (5)	5 (6)	6 (5)	1 (1)	1 (0)	5 (3)	1 (2)

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CREATIVITY SHAPING IN ENGINEERING EDUCATION TRAINING

University of Ben-Gurion of Negev, Beer-Sheva, Israel
V.I. Livshitz

The article considers a complex problem of creativity training in engineering education. Creativity of engineers is based on the overcoming of "immaturity". There are analyzed proposals suggested in V. I. Livshits's paper on the problem of creativity shaping in the course of engineer training an engineer. It is specified that it is necessary to optimally combine fundamental and professional training rather than substituting fundamentalization of engineering education for professionalization.

Key words: *competence, epistemologist, erudite, system design engineer.*

V.I. Livshitz

Problem situation.

The rushing growth and over-complication of techno-sphere and info-sphere further the development of a new entrance criteria matrix for engineers working in hi-tech, info-tech and science-tech areas. The cooperation personnel departments widely use different methods in evaluating the creativity level of this or that applicant.

As in many cases, the production requirements in techno-sphere have forestalled today's Engineering Education (EE). Currently, the practical aspects of the EE functioning system and its modules are beyond the problems of creativity learning. Numerous institutions, faculties and departments are overcoming the Educational Gap (EG) – lagging from today's reality and EE and yesterday's innovations in the techno-sphere. Employers have coined this phenomenon as EE crisis, the results of which are graduates – engineers «in-white», i.e. erudites, being unaware, fearing and avoiding any activity in techno-sphere-enterprises. Enterprise workers nicknamed such graduates as an «embryo» engineer.

Periodically, universities have made attempts in overcoming EG. However, all attempts resulted in the swapping of «embryonism» to incompetency of the graduates, i. e according to S.N. Parkinson «rust of civilization» [1]. Incompetency to ignorance has been flourishing like a flower within the sphere of EE. The introduction of international EE (MC EE) [2, 3, 4, 5] is based on the competence approach involving the EE requirement to train graduates with a high level of professional competencies (PC).

Thus, the EE problem domain can be expressed as: through the overcoming of «embryonism» and incompetency to high professional competence and only in this case further the shaping of graduates' professional creativity.

What is the role of creativity within the framework of EE? As a matter of fact, some intellectual-scholars affirm that any technology, including engineering, should develop only convergent thinking; while creativity is oppositely directed, i.e. it is based on divergent thinking contrary to logics.

This concept should be left behind. The problem involves the differences in learning motivations (ambitions, education models-EM) for various student groups. One of the basic EE educology axioms established the following EE targets:

- EM -1– EE brand to improve the individual social status
- EM -2 – EE training competitive professionals for the labor market
- EM -3 – EE ethic imperative to promote erudition (knowledge) within sciences
- EM -4 – EE selection and training of elite social-ranking leaders and groups.

Every education model (EM) has its own specific education program (EP). Training students from different EMs in one and the same «cauldron» is a widespread mistake.

It is obvious that training «everyday» engineers is not the training of the weaker ones, but it is the EE for those aimed at EM-2, but not EM-3. The fact is that for more than 150 years, undergraduates were and are the basic suppliers of professional engineers for the techno-sphere.

The computer revolution created the illusion that the modern intellectualization of the technological environment sharply diminishes the role of engineers «in -black» and, in its turn, resulted in the swapping of engineers «in-black» to engineers «in-white». The most exalted amateurs formulated this as:» Today's engineers is a group of specialists «in-white» swarming around a computer». But this illusion has vaporized –a technician and an engineer «in-black» continue to be the «heart and motor» of a modern techno-sphere.

Creativity in the shaping of future creators «in-black» should differ fundamentally from the upbringing of those wunderkinds stuck to the PC screen.

The multi-year experience of an engineer – mechanic embraces the seven areas of professional activities (PA) – product engineer, technician, production line manager, commissioning engineer, analytic expert, teacher and system-design engineer-generalist. The shaping of creativity should include a specific feature for each of the above-mentioned PA areas.

The objective of the first six PA areas (project, distribution, support, provision and prevention) is to provide a long-term stable operational period of one selected segment or element within the techno-sphere. And only one PA area (system-engineer generalist) is involved in the development of the advanced innovation strategies and tactics to provide a balance of interests within «the stability of PA, i.e. adequacy of its innovative breakthrough».

There are two possible engineering stages in the process of practical info-contacts of the engineer with the techno-sphere activities:

A. Designing a virtual project of this or that object, then a description of the item, system or technology from the standpoint of an external individual, i.e. project engineer, the person making decisions and etc. Implementation stage of proposed innovation is exclusively the result of trivial and routine actions without any creativity.

B. Acquisition of modern process design or technology to obtain efficient results within the real techno-sphere and external environmental conditions in overcoming the ins and outs and existing entropic contradictions arising in the implementation process of this or that innovation.

These stated problems are solved through unconventional, experimental, heuristic and creative decisions and actions. Only the law of the end consumer functions, i.e. prosumer- «producer + consumer», all in one.

Both engineering stages should be reflected in EE while shaping creativity, as the PA content in both cases is quite different.

Creativity (creative) is the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena and to generate solutions.

Technologically, creativity is the perceptive of achieving a target, finding a way out in dead-in situations, exploiting climate through uncongenial and ingenious solutions by unexpected resources and tools. Creativity has a specific feature- its flexibility in approaching strategies and withstanding stereotypes.

Analyzing the problem area in EE (as stated above), we'll examine the overcoming stage of «embryonism» and incompetency. The following problems should be solved at this stage:

a. Decisive learning concept updating in EE- substitution of EE fundamentalization (FEE) for professional EE (PEE) [8]. It should be noted that PEE, injection of concise technological solutions into the theoretical university matrix, has been the Russian education principle, implanted in the 19th century from European (German) EE.

The work [9] can be used as an EE-based innovation pattern example for curriculum of different departments. Today it's not difficult to find education programs (EP) in Natural Science based on the PEE concept principle both in Russia and abroad, which, in its turn, have elapsed through a long-term testing in prestigious universities and received Russian and international accreditation. For example, the brilliant achievements of academician V.S. Pugachev, who modernized the teaching of higher mathematics at Moscow Aviation Institute (now, State University of Aerospace Technologies), were based on four proposed didactic principles [10]. It would be more challenging to develop EP clusters, implementing the PEE concept and receiving international accreditation.

b. Actively processing educational engineering- technological systems, primarily flexible computer-aided design of production and management [11].

Basic engineering packages, software systems used in the techno-sphere, should be selected, avoiding the application of previously tailored curricula. Students supervised by tutorials should be able to master such unfriendly systems.

c. Introducing certification- testing for profession-oriented teachers.

d. Reviewing the student impersonal approach in the organization of learning groups, seminars and student streams. The present «cauldron» approach unites in one and the same auditorium both «in-black» and «in-white» engineers, professionals and erudites, future production managers and researchers.

If you look through today's windows you can see the XXIst century – a century of single-item (limited) production, target-focused customer services, and unhesitating conversion from «building (convection) to «boutique.» The EE system should also transform, involving such well-known reformation methods as for example, intensive target-oriented professional training (ITPT). Group teaching and student streams should gradually disappear, being replaced by individual (tutorial) teaching.

e. Sequence of education disciplines can be compared to a «Screwdriver factory», i.e. machine assembly line – loose parts are manufactured, units, blocks and separate mechanisms are assembled, then the whole machine itself.

This analog can be relevant to the development of skills and abilities throughout the Natural Science cycle: units – skills obtained in the engineering and professional disciplines and reinforced in term project; the machine itself- graduation paper or project in which everyday engineering problems are being solved. The mental equivalent of this project would be the creation of a graduate engineering thesaurus. This is the so-called Papert principle – constructionism [12] – based simply not on acquiring new skills, but on acquiring new administrative ways to use what one already knows.

In conclusion, it can be stated that implementing the concepts in items a-e would further the minimization of «embryonism» and incompetency.

Experimental knowledge and heuristic solutions play a key role in professional and engineering disciplines (techno-knowledge).

Accordingly, it is essential to boost the engineering training level within the professional competencies as following:

1. engagement of skilled practitioners in key EE problem-solving;

2. knowledge of engineering graphics is a vital tool for any engineer; however the student's knowledge level in this subject is rather low. The reason is very simple-engineering graphics, as other subjects, has been significantly

computerized and has excluded the basic principle of engineering didactics- «The brains are developed by hands»;

3. obligatory propaedeutic courses in professional technology, including practicum based on practical data and material;

4. obligatory internships as an engineering term, where the student perceives the axiom of successful professional activity – « the devil in the details»;

5. development of institutional standards in determining the content of engineering sections in term and graduate papers.

These measures should decrease the EG level in EE. However, resolved elimination of EG is possible only when feedback would be included in the EE module structure, i.e. the index of evaluating the «EE product» by consumer-employer.

The subject of educational activities, i.e. not only the object, but also the subject of engineering learning, is a complex techno-sphere section, in many cases, the engineering-technological system (ETS), through which a person enters the info-sphere to study and attain it for further pragmatistic application. This becomes the bench-mark in determining the problem statement of professional engineering creativity.

In shaping legitimate creativity only accredited and proven knowledge, as a gnostical student mentality model, is used. How this would work is based on the analysis of the two primary postulates in modern epistemology which were formulated by the famous XX-century educator Seymour Papert:

1) One can not be taught – one can only learn. Every person is an (epistemologist) educator by himself.

2) No instructions- only mental constructions- the only tool in learning and teaching [12].

Modern neuropsychology has fully proved the functions of the 2- brain hemispheres. The brain comprised of right and left hemispheres, each of which is responsible for different functions. The right hemisphere controls many of the body's thoughts and actions- intuition, spatial thinking and creative thinking. Inventors have a pronounced left hemisphere, which controls the analytical and logical thinking, organizability and such an important quality as opinionated; i.e. a person of strong principles, obsessed on one's ideas, «finely-honed.» Based on the above-mentioned factors creativity is the result of the thinking function of two hemispheres.

The central chain in EE didactics involves no lectures, no tutorial classes, and no instructions- but only actions, either mental or physical, to complete complicated techno-sphere activities. «To understand one must begin to understand empirically then learn from empiricism to general. To learn how to swim, you need to go into the water» (Lenin).

«Self done is soon done!» Don't wait until something happens, many things can be learned only through different actions and processes but not otherwise.

The up-dated level of the complicated techno-sphere furthered the development of new learning systems based on computer-based simulators, i.e. instructional engineering. During learning a person can generate specific dynamic objects- images. Such temporary objects were considered to be «hybrids» – man + techno-sphere objects and termed as virtual («virtus»- inner). Natural sciences can not explain the energetic activity mechanism linking man with «active» techno-sphere objects. However, the number of recorded facts increased so rapidly like «symbiosis» which is impossible to ignore. In the last 25 years these facts were interpreted and generalized resulting in the emergency of virtualistics – virtual psychology. N.A. Nosov in his monograph wrote: «Virtualistics is not a science, but only an ontological approach which can be applied in any science.»

In psychology and educology virtualistics legitimated the application of a new object-image (virtual) occurring as a result of a person's activity experience. There are two methods in using the simulator or visual object: detached or implanted, i.e. virtual. In the latter case, the image becomes «personal», which rejuvenates the activity itself, making it rather real. If a person finds himself \ herself in a blind alley and continues solving the problem, then the virtual emerges. This develops into creativity-insight, inspiration, understanding, etc., for example: virtuoso-machine operator becomes an integrated part of his machine - tool; driver feels that the vehicle is an organ of his body, even mind; pilot finds out plane possibility frontier and so on. A synthetic specialist manufacturing some products on a unified hardware/software system and mastering all the details of this operation process becomes its «lord» – creator. It can be stated that virtuals are very common in engineering. Systematology [17] promotes the virtual approach for complex systems in technosphere and info-sphere.

Proponents of the EEF (engineering education fundamentalization) are convinced that the shaping of engineer creativity and the cultivating of future creative researchers are synonyms. This is a deception: teaching creativity within EE is considering the examination of heuristic solutions, the core of which is the synthesis system and their acquisition. In engineering, creativity involves the development of new contradiction methods and tools to overcome the «attacks» of engineering solutions. Excluding these facts, humanitarian-erudites suggest using didactics, as a major tool in shaping creativity within EE methodology background of Soviet physics-mathematics school (PMS).

Many didactic scholars introduce PMS methodology as an example-pattern in avoiding teaching through ready-made algorithms and standard problems which they termed as «ill-provided teaching».

According to these theorists, creativity develops only under the conditions of non-standard sophisticated problems. However, in many cases, such problems are purely theoretical or even scholastic ones and not connected with the student's future profession. Academician L.D. Landau stated «the brevity of life does not allow us to enjoy the luxury of spending time on problems which lead us to no results!»

Technology transfer to the «creativity level» is the dark-side of our brains, invisible to both students and teachers simultaneously. There is no proof that non-standard problem solutions could spur creativity and, visa versa, standard problem solutions could not. There is surpassing evidence that rejects the above-mentioned statements. For example, TIPS / TRIZ (theory of inventive problem solving) developed by Genrich Altshuller. Following Altshuller's insight, the theory developed on a foundation of extensive research covering hundreds of thousands of inventions across many different fields to produce a theory which defines generalized patterns in the nature of inventive solutions and the distinguishing characteristics of the problems that these inventions have overcome.

Psychology reveals the most complicated processes hidden under the mask of traditional didactics. The most important characteristic feature of presenting standard and conventional algorithms and solutions is the fact that these samples are models of elegant solutions in overcoming dead-end situations and dead problems. .

This is also an example of implementing the principle of knowledge- technology change-over. Critics of traditional didactics distinguish that cognitive teaching aspect is «ready-made algorithms.» But there is a B-side, i.e. emotive (affective) aspect which is also significant in the teaching result process. It is this aspect that boosts the classical elegant standard solutions in teaching.

It is obvious that comprehending classical solutions has become the backbone and stepping – stone in shaping creativity. Very often, classical solutions can not be formalized and their description is only verbal and illustration and reproduction - only visual. In EE solving standard problems is not teaching stereotypes, but it is teaching standards. Teaching professionals on the basis of previous elegant classical solution thesaurus has been and will be the founda-

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tion of shaping creativity in EE. Studying methods and tools to overcome the past contradictions and barriers results in the development of personal tools and creativity pattern-models.

Fundamentalists interpret «the ability to think» as the ability to make correct problem solutions. However, as mentioned above, according to the professional approach, the problem-solving decision is only the first step in shaping engineer creativity, as the next step involves the implementation of the solution itself in response to the entropic contradictions of techno-sphere and eco-sphere. It is the engineer's creativity that embraces the ability to overcome these contradictions, otherwise, there will be a zero result: «We wished our best, you know the rest.»

The characteristic features of creativity – particularization and professionalism- are applicable to the profession of production engineer, which, in its turn, is subdivided into seven areas.

1. Product engineer – CAD/CAM system engineering showed that the articulation and specification of item (part) production problems in several technological spheres, for example, fabrication and instrumentation, can simply be done by computers. In other words, the product engineer activities are more heuristic than that of the technician.

Today CAD/CAM systems only help the product engineer in designing his / her ideas into a model. There are no intellectual expert-type systems by which the product engineer could enter into the global information database or databank to understand where, how and what is vital in solving this or that problem professionally. In the meanwhile, non-traditional design methods are widely applied, in which numerous designing stages of the tangible object are omitted. Product engineers- «agregatists»- use these methods, excluding the preliminary designing stages and tackle the first machine sample through the «trial-and-error» method by using makeshift means, i.e. time-expired or dead parts, units and blocks. Such actions can be explained if you take a look at the Latin word «construction» which literally means «building, composing». Hundreds and hundreds of successful solutions have been found by «agregatists». It's appropriate to remember the following proverb again «Self done is soon done!» That computers have significantly modernized this unconventional design method can be seen in the development of powerful graphic engineering systems of virtual reality (VR). They are used in designing complex machines and machinery systems where concept design, component coupling, nodal testing and total unit assembly are conducted before the implementation of the physical prototype. This concept is termed as Product Lifecycle Management: Virtual Environment, Virtual & Augmented Reality (VE & VR).

As creative engineering thinking still embraces the empiric and heuristic methods, avoiding formalization, the teaching role of mathematics is rather low. In this case the alternative mathematics can be – TIPS (TRIZ), i.e. theory of inventive problem solving including a series of exercises to develop imagination. Genrich Altshuller, the author of TIPS (TRIZ), proved that all techno-sphere objects develop according to one and the same law and revealed a general strategy –« searching compass»[19]. TIPS (TRIZ) spread widely throughout the world and became a powerful tool in initiating creativity. Gradually the theory of TIPS (TRIZ) developed into the theory of intensive thinking (TIT). A methodological teaching process example of TIPS (TRIZ) in EE can be found in the works of B.S. Sergeeva [20].

2. Technician – is an active participant in both A and B stages of the professional engineer activities within the techno-sphere itself. Today segments and elements predominate in the techno-sphere, showing a high functional level of both physical and informative automatization. To define such techno-sphere components the following terms were introduced: EPS- engineering production system; EPS DT (digital technology)

– machinery and instrumentation which are the objects of techno-sphere to transform these production objects, specified by design information (DI) through tools and instruments, defined by technological information (TI). EPS DT is a complex including people, technological machinery, automated storage-retrieval system and control systems.

Today, it is possible to come across the consequence of «computer euphoria» as the ignorance of technological information (TI) in the production of an item. There is only way to develop a professionally competent technological process – automatic engineering information (EI) transmission through technological information (TI). This is an eternal axiom of technology. Namely this is what is implemented in the integrated engineering design scenario: a combination of formalized CAD/CAM processes and the heuristic interference of the technician through an interactive PC transput.

The professional kit of a technician is described in «Mechanical-Engineering Technology.» Accordingly, professional knowledge can be divided into three clusters: (1) scientific; (2) ethical and (3) expert. The technician often applies one of the three clusters in the TI search for heuristic solutions. However, these clusters do not embrace 100% of all thesaurus technological knowledge. A large volume of knowledge in technology algorithmization has been generalized through CAD/CAM systems. In this case, it is advisable to design special courses in technology, including «Algorithmization of geometrical items and technology: general solutions in CAD/CAM systems.»

The so-called Landau studies have widely spread throughout the developed countries in the field of EE [21], which the author himself termed as algo-heuristic teaching theory, whereas it is unknown in Russia. Abroad this theory is applied in the teaching of effective mental activities within the framework of many different spheres. Due to its astonishing success the Landauians called it «Lev Landau miracle.» The introduction of Landau theory into the Russian EE would accelerate the programmed and adaptive learning on the basis of computers and further the shaping of creativity of future engineers.

The most difficult stage for the technician is stage B- engineering production system (EPS). According to V.V. Druzhinin and D.S. Kontorov, N.N. Moiseev and Stafford Beer, EPS can be associated to cybernetic systems (CS). The basic EPS components are «cell»- technology, while the technology nucleus transferring «genetic» burden - information.

Thesaurus block, i.e. environment info-model and the system itself are typical for environment imaging and self- imaging in CS. Thesaurus block is the study problems and EPS development. Learning subjects in EEC – tutor and expert are part of the info-contact with EPS as a technician, mastering it, and then creating a symbiosis, including intellectual system or temporary CS. Temporary CS is the basic instrument in mastering the complex techno-sphere systems.

Education programs (EP) should be ensure the provision of education EPS- a «table microfactory»- at every department [11]. Based on this EPS a student in contact with his or her tutor learns to develop temporary CSs.

The student develops the most important professional competencies (PC) for a future technician in overcoming the contradictions of the techno-sphere, i.e. both physical (contact with the machine tools, facilities, instruments) and informative (info-contact with PC, CAD/CAM systems and CNC controllers).

It should be noted that the described scenario provides the optimal teaching combination of PC simulation and physical production of objects. This is very important in shaping creativity requirements in EE.

3. Production line manager. The engineering area requires additional knowledge, skills and abilities in management, ergonomics and engineering psychology .

Another essential aspect is a long-term internship (so-called «engineer

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term») as production department manager, as well as, including the following sections in the graduation project- economics, ecology, business management and HSE.

It is necessary to study the experience of the leading corporations which have been applying sophisticated software clusters. The most effective are such complexes as «e-Manufacturing for e-Business».

Creativity of production managers involves mainly such an aspect as leadership. In many cases the creative manager selects the conducting method - conscientious authoritarianism, which does not suppress but, visa versa, stimulates creativity in his or her employees.

Progress is not promoted by systems, but by individuals; where systems are simply activity tools of these individuals.

The experience of different leaders should be duplicated. In argument to Peter principle [22], S.N. Parkinson stated [1]:» That the boundary of competency is established once and for ever – nonsense. This is a myth. Our experience says that we live among people different in their astonishing competency.»

4. Commissioning engineer – requires deep knowledge, qualified skills and professional abilities in diagnostics, engineering graphics, engineering systems of virtual reality for database control, testing and application, electrical equipment and electronics, HSE facilities. To require the vital «creativity luggage» in commissioning operations one must work in-situ through «clinical» and teaching methods.

5. Analytic expert – requires versatile training in meteorology, reliability engineering, production quality monitoring, and laboratory methods in research and even in criminal investigation. This engineer should have a high professional level in such aspects as standardization methods and knowledge of international standards, as well as, professional training in patenting, industrial jurisprudence and international laws.

6. System-design engineer-generalist - technological innovations and globalization are the two major dynamic world vectors of the XXI century. The basic job of a system- design engineer-generalist is to develop the strategies and tactics in each stage, as well as, analyzing the process as a whole. Here the engineer develops such qualities as creativity, non-standard approach and «surprise» decisions.

Innovation not only blows up the techno-sphere itself, but also transforms individual's thinking process (mentality). Not every manager is inclined to change and adopt this or that innovation strategy. Here arises the collision with inertial resistance, especially inertial human resources.

Today all project operations are conducted on PC by the system- design engineer-generalist, due to planning production VR system development engineering which uses the following information technology- CAD/CAM/CAE to design virtual workshops and plants, undergoing further testing to technology, production and organization.

7. Teacher of profession disciples – this professional area is not considered in many cases. There is a very simple primitive stereotype: «Any student can become a teacher in professional disciplines as he \she was taught.» .

The first and obligatory requirement for a teacher is have some engineering experience (years in firm/company/profession/business. Another requirement is extended education in engineering pedagogic. In the leading Russian engineering universities there are engineering pedagogic institutes, department or faculties based on the IGIP principles (Ingenieur Gesellschaft fur Internationale Planungsaufgaben) – international engineering education organization.

For more than 50 years IGIP develops the register of professional teachers in engineering pedagogic, having received the «ING – PAED IGIP» (European

/ International Engineering Educator) status.

Teachers of ING – PAEG IGIP status have to be extremely creative. The reason is very simple- he or she has to overcome vast entropic contradictions in his or her professional activities. The EE system models are far from being adjusted to the teaching process perfectionism. There is a tendency of «hoisting» these subdivisions to false homeostasis level. Don't forget the well-known axiom «The harder the teacher, the better the student.» The teacher must always remember to be in the shoes of his or her student. However, teachers forget or even don't want to remember this skill. Why? A teacher has to spend a gigantic amount of time in lesson preparation, in laboratory, in workshops and, of course, at PC. But the most striking target is to arouse the slumbering creativity in the students. One of the most famous mathematicians David Kazhdan (Harvard, USA) stated:» Intuition requires effort. The more the effort, the more the intuition.»

Learning has become a «companion» throughout the life of a person in the XXI century. Engineer-pedagogue should masterfully possess sophisticated technology, software and hardware. In this case tutors, trainers and gurus having PC in using sophisticated technology and techniques in ESP techno-sphere and info-sphere are more vital than the lecturers reading theoretical subjects. It is they who will become the real creative people in one's professional area.

Conclusion

More often than not, in many respective university departments there are professors who are «ivory-towered» in their professional area for more than 15-20 years. They «play the devil with the students.» The change-over of knowledge, skills and abilities and the development of professional competencies should be developed within an atmosphere of perfectionism, but in a dull virtual or virtual imitation of reality.

Thus the main problem –solving of managers in the EE system models is the everyday struggle against entropic «erosion», which is constantly attacking all the components of the university life- beginning with the classrooms, halls, campus and ending with «creeping» tendency towards non-functional education

The shaping of EE graduate professional creativity can be shaped only within an atmosphere of perfectionism.

TERMINOLOGY ABBREVIATIONS

VR– virtual reality
SES –State education standard
DT – digital technology
NS – natural sciences
KSA –knowledge, skills and abilities
EA– engineering area
EI– engineering information
CS – cybernetic system
MAI– Moscow Aviation Institute
IEES – international engineering-education standards
IE – instructional engineering
EP – education program
PA – professional activity
EEP – engineering education professionalism
PC – professional competencies (competency)
EP – education paradigm
EPS – engineering-production system
SBF – specific brain functions
MMS – "man-machine" system
TI –technological information
TP – technological process
TIPS – theory of inventive problem solving
TIT –theory of intense thinking
EEF –engineering education fundamentalization
PMS –physico-mathematical school
CNC –computer numerical control
MMI – man-machine interface
CAD –computer aided design
CAE –computer aided engineering
CAM –computer aided manufacturing
CS –computer sciences
EE –engineering education
EG –educational gap
PC –personal computer

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Creativity training in engineering education

Siberian Federal University
S.A. Podlesny

There are analyzed proposals suggested in V. I. Livshits's paper on the problem of creativity formation in the course of training the engineer. It is specified that it is necessary rather to optimally combine fundamental and professional training than to substitute fundamentalization of engineering education for professionalization.

Key words: *fundamentalization, interdisciplinary activity, creativity, innovativeness.*

S.A. Podlesny

The article by V. I. Livshitz "Developing creativity training in engineering education" is published in this issue. It considers the actual problem of training creative personality, capable to provide significant positive changes in the field of engineering and technology within post-industrial economy, which is characterized by the intellectualization of the industrial environment.

The author draws attention that today engineering education (EE) system is significantly distanced from the task of teaching creativity. This situation, according to him, leads to the fact that many graduates avoid working at techno sphere enterprises because of their low level of professional competence.

These are author's key proposals how to update the concept of engineering education:

1) replace fundamentalization of engineering education by professionalization;

2) increase capacity of educational engineering - education and technological systems, to avoid the use of adapted training systems;

3) initiate tests of professional knowledge for teaching staff;

4) review the current impersonal approach to the formation of student groups, when people with different profiles of training have to study together;

5) make a chain of subjects following the basis of machine assembly: details – components - car.

It is difficult to accept the first proposal, because fundamentalization of scientific basis of engineering knowledge and engineering is the background for training future professionals. It makes sense to speak of optimal combination of basic (fundamental) and professional training. Obviously when studying fundamental subjects students need to clearly understand how these knowledge can be applied in their future careers. Therefore, even the teachers of mathematics and natural science must be aware of the specifics of professional activity (specialty) in different training directions of students. It is important to introduce innovative educational programs that are integrated into the global educational environment that will contribute to the continuous basic and specialized training and are oriented to the solution of inventive problems.

Concerning the ban on using adapted training systems, it is unlikely that this can be done at an early training stage because of the high cost of industrial systems. However, it could be implemented for upper division courses with effective interaction of university and industrial companies.

One of the important requirements for teachers of engineering disciplines to have work experience at modern enterprises, research institutes or engineering design offices. If it fails, then such teachers must necessarily undertake the internship. Necessary condition – efficiency of completed research projects and management students' research activities. Then there will be no need to make special tests for teachers. In addition, there are standard procedures for determining the qualifications of teachers before approving them on position.

The author examines in detail the ways of solving the problems of the formation of creativity in relation engineering qualification with specialization: designer, technologist, production line manager, commissioning engineer, analytical expert, systems engineer, professional disciplines teacher.

Unfortunately, it is not indicated that innovative thinking and high creativity it is a combination of creative, strategic, systemic and transformational thinking activity, which should take place on the basis of interdisciplinary knowledge [1]. From this point of view it is necessary to perform interdisciplinary course projects within each educational program.It is crucial to use such form of cognitive activity as interactive learning, and one of its options as interaction with the student's learning environment based on the actual production process. The following elements of interactive learning can be implemented: virtual systems, automated training systems, simulators, full-scale working models of equipment [2]. It is important to create a learning environment which is adequate to the prospective technological system in real industrial sector. Modern production - is often dispersed ("network") production, which requires the ability to form a network to work in an interdisciplinary team, including the use of information and communication technologies. Therefore universities should create virtual ("electronic") ventures together with industrial enterprises.

It is reasonable to ensure that a flexible automated system became a part of electronic network of the company, equipped with modern machinery equipment, which allows the output to have a specific product. Using electronic network enterprise in education process will generate extremely relevant skills: creating an interactive environment for a group to design and develop real product and implement interdisciplinary approach, creating structural pattern of innovative products, electronic definitions of all stages of the life cycle of innovative products.

The author points out that an important role in preparing the next generation of engineers should be devoted to the Theory of Inventive Problem Solving, a proven and effective tool for creativity initialization. This is a really urgent task for the universities.

In general, training of engineers capable for creative activity, requires close collaboration of universities and innovative companies at all stages of the life cycle of professional engineer development.

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Review of accreditation of engineering educational programs In Lithuania

Saint-Petersburg State Electrotechnical University "LETI"
S.O. Shaposhnikov

The paper presents review of the specific features of legislation documents and further implementation of external independent assessment of engineering educational programs in Lithuania.

Key words: *Higher education institution, engineering education, engineering degree program accreditation.*

S.O. Shaposhnikov

Introduction

These notes give readers a kind of understanding, perhaps not complete enough, on how accreditation of engineering educational programs in Lithuania is organized. At the same time, they allow us to estimate the level of development of the accreditation system of educational programs (EP) and especially its implementation in the country.

Organization of the accreditation process of EP

According to the Law on Higher Education and Research [1] only those educational programs of higher education degree that passed through accreditation procedure could be introduced at universities of Lithuania. Since 1999, the accreditation process is based on the external evaluation. The programs can be accredited for 3 years (short term) or for 6 years, moreover all new EP developed at universities may be accredited only for 3 years.

In contrast to many countries, accreditation of educational programs in universities of Lithuania is organized by state agency - Lithuanian Center for Quality Assurance in Higher Education - SKVC[1]), established under the Ministry of Education and Science of the Republic of Lithuania and financed by the state budget. However higher education institutions can apply to any accreditation agency from the list of those that are included in the European Quality Assurance Register for Higher Education[2]. Although one should keep in mind that the final decision on accreditation of EP could be taken only by SKVC based on reports of the external evaluation.

Within 2010 year the Center evaluated 194 educational programs[3]: 95 EP were awarded full term accreditation, 95 got only short term accreditation, 4 educational programs were not accredited. Similar statistics of 2011 year is as follows: total number of evaluated EP - 141 OD, 61 EP (43%) – full term accreditation, 79 EP (56%) - short term accreditation, 1 EP was not accredited.

So, the first thing attracting attention in the accreditation process is that evaluation of EP is performed by an international group of invited experts. Since recently these groups consist of representatives of the academic community from different countries. Of course, it helps to minimize the chance of any

[1] *http://www.skvc.lt/en/?id=0*

[2] *http://www.eqar.eu/*

[3] *Statistics was kindly provided by SKVC governing body*

influence on the accreditation result by personal and professional relationships and preferences. On the other hand, this means that the process of accreditation - from self-study report to on- site expert-team visit and preparation of reporting documents is run in English. And this fact still could be a matter of some difficulties for universities applying for accreditation.

One of the main documents regulating external evaluation of educational programs called "Procedure for the External Evaluation and Accreditation of Study Programmes" [2], was approved by the Order of Ministry of Education and Science in 2009. According to the introduction of this document, procedure for accreditation of educational programs has been produced in compliance with Standards and Guidelines of ENQA[4]. The process itself is well structured and regulated. Some materials like sample questionnaires for meetings with administrators, students, etc. were elaborated in order to help experts during on-site visit to the university. Moreover it is also worth mentioning that the assessment of EP is run in a "package" way - one group of experts evaluates several related EP (probably in different higher education institutions). This maximizes the use of professional experience of experts in their fields of scientific and pedagogical competence, although requires moving to other cities to visit different universities[5].

Evaluation criteria

Let us consider briefly the Evaluation criteria of engineering educational programs at universities of Lithuania.

Criterion 1. **Program aims and learning outcomes.** First of all, EP objectives and its learning outcomes must be clearly defined and understandable, and information about them should be available to all interested parties. Of course, they must correspond to the level of education (Bachelor - Master) and the method of study (full-time or part-time). In addition, the content of the EP should closely match foreseen learning outcomes and qualification awarded upon graduation.

It should be noted that almost all EP, which I had a chance to evaluate satisfied this criterion. In comparison with accreditation practice in Russia – this information is not available at all Russian universities.

Criterion 2. **Curriculum design.** First of all, the structure and content of the EP must meet the requirements set in the regulations of the Ministry of Education and Science. [3] This applies not only to the general complexity of the EP, but the minimum number of disciplines in each block. So, in EP of bachelor level studies in mathematics and natural sciences must be of at least 24 credits including at least 14 credits for studies in mathematics. At least 30% of study load should be allocated for specialization disciplines, and at least 20 credits must be allocated for an internship. Not less than 10 credits - to prepare the final qualification project (report). At least 5% of the total study load should be available for optional disciplines chosen by students. At the same time, such disciplines may be outside the domain of specialization of the student. It is also allowed to study these disciplines at other departments of the university or other higher education institutions. Study load should be uniformly allocated within one semester as well as throughout all semesters. One of the major informal requirements of this criterion - EP content should reflect the latest achievements in research and technology. When evaluating the EP experts pay much attention to its compliance. In addition, the content of the EP and educational technologies must ensure the achievement of program learning outcomes by all the graduates - and this is also evaluated very carefully.

Criterion 3. **Teaching staff.**

It should be noted that ministerial requirements for the teaching staff of EP are quite strict. Thus, at least half of the

[4] *http://www.enqa.eu/*

[5] *In contrast with the accreditation visits organized by AEER (Russia) or CEAB (Canada), where a team of experts can evaluate several EP but at the same university*

teachers involved in the undergraduate programs should be associated professors or professors with some teaching experience within the last three years. They should be actively involved in research in the relevant field of the EP and annually have at least one scientific or educational publication. Teachers are required to be able to speak fluently at least one of the major languages of the European Union (English, French or German). Although, honestly speaking, it must be recognized that this requirement is not always met. Of course, teachers need ongoing retraining, and university should provide appropriate conditions for this. The faculty membership in professional societies and associations are considered as advantage in program evaluation. As a rule, professional skills of teachers are evaluated by students, availability of such evaluation instrument and its efficiency are of important consideration within EP accreditation.

Criterion 4. **Facilities and learning resources.** First of all, all classrooms must meet the requirements of health and safety – and it is quite natural requirement. Lecture rooms should be equipped with modern video and audio presentation equipment – to be fair this requirement is not met everywhere and the situation with classrooms' technical equipment is quite similar to many Russian universities. Each EP should have a plan for regularly renovation, improvement and development of its facilities, including laboratory equipment and software – EP evaluation criteria take into account implementation and effectiveness of such plans. One cannot deny that real equipment used for studying process at universities in Lithuania is modern enough and of high quality, and that is quite obvious. However, at some higher education institutions as a result of co-operation with industry, business and European development programs, the quality of equipment of educational laboratories is really high. Of course, all EP disciplines should be provided with textbooks and access to online information sources - it is an interesting point to be made that books in Lithuanian, English and Russian languages, including even those published in the Soviet Union are available for students as reference and training materials. As a rule, the level of disciplines' information support is quite high and university authorities pay enough attention to this aspect.

Criterion 5. **Study process and students' performance assessment.** First of all, EP admission rules should be clearly formulated and available to interested parties. Obviously on the undergraduate programs (bachelor level) school graduates are mostly accepted. Applicants submit their applications in a centralized way, indication the first, second and third desired universities and study programs. Universities are naturally interested in admission of first-year students - each of them brings some funding. This funding is fixed for each school graduate and, therefore, there is not any plan of central funding of the educational activities at universities. Like at Russian universities, within the first year quite serious attrition of students about 30% could take place - universities try to take measures to reduce this dropout. However, in contrast to the practice of Russian universities where attrition of students is often caused by insufficient level of training upon school graduating, the main reason for Lithuanian attrition of students is their disappointment in the chosen educational program and a desire to change it.

As for admission to master degree programs – there is a system of entrance tests. And those who were bachelors yesterday are not forbidden to cardinally change their area of specialization - to pass the entrance exam successfully is the most important condition.

An important issue in the analysis of any EP is the system of students' knowledge and progress evaluation. The first and basic requirement - the system must be clear, and the information about it - available to students. As a rule, universities of Lithuania use students' performance assessment system based on scores and ranking. Meetings with the students of different universities have shown that from the very beginning of studying process they are aware how their academic performance will be assessed and what principle is used for their final assessment.

One of the sub-criteria of criterion 5 is the availability of opportunities for students to participate in academic mobility programs. According to the accreditation procedure Association for Engineering Education of Russia experts, estimating the performance of this sub-criteria take into account the fact that there is at least a system of informing students about the opportunities of academic mobility. It is no secret that in Russia there is not yet any system of organization and financial support for academic mobility at the state level. As a consequence, this criteria establish quite soft level of compliance for Russian universities. The situation is different in the country-member of the European Union, where there are special programs to support international academic mobility, including the necessary financial arrangements. Against this background, it was surprising to learn that the number of students going to other universities and countries is very little. As an explanation of this fact raised the point that students of master (as well as bachelor) programs, as a rule, have somewhere to work and the lack of a semester is threatening them with loss of their jobs.

Moreover, to provide master students favorable conditions to combine studying with working some universities reserve evening time for classes, believing that this approach to the organization of the training process makes the EP more attractive to students. I must say that an international group of experts, which I had opportunity to join, did not agree with this approach, believing that the efficiency of training in the evening cannot be as productive as in the daytime. In addition, this approach significantly reduces the time available for the students' independent work - and this time is accounted in the study load of the EP. And finally, not all students have jobs that match their future professional field.

One more sub-criteria of this criterion - most graduates from the EP should work in accordance with the awarded qualification. I must say that at universities of Lithuania that I was able to visit interaction with alumni is organized really well. As a rule, there is a system of graduates' career monitoring and support, graduates' opinion is regularly collected and accounted in order to improve the EP.

Criterion 6. Program management. This criterion includes, above all, a clear division of rights and responsibilities to improve the EP (decision-making, monitoring, implementation, etc.) among academic administrators. Information on the implementation of the EP should be regularly collected and analyzed. It should be noted that the primary method for collecting information is to ask students through a survey, which is conducted at the end of the studying process of each EP discipline. In addition, there is a need of regular feedback from graduates and employers - all this information should be used to improve the EP. And it is also very important to make received information available to all stakeholders of the educational process.

In practical terms, experts are often especially interested in two of the following aspects: how (to what extent) students' and employers are involved in the process of improving the EP. According to the experts opinion I had chance to talk with, it is not enough just to make students questionnaire survey and make adjustments of EP. It is also necessary to inform students about how their views are taken into account, and what changes are made in the implementation of the EP on the basis of these opinions. This, according to experts, motivates students to impact surveys, and it is hard to disagree with this fact.

The involvement of employers in the improvement of the academic process in general and specific EP, in particular, is also the subject of special attention. Industry representatives (business) have to participate in the collective governing bodies of the university. Their opinions should be analyzed and used not only to form set of modules and content of EP disciplines, but also to in develop overall program objectives and learning outcomes. It should be noted that the learning outcomes are not listed in the state educational standards by specialty –there is only a set of frame competencies for almost the entire range of engineering educational programs and universities, based on these framework requirements, formulate learning outcomes for specific EP [6].

In general, it should be noted that the evaluation criteria of the EP used in Lithuania are very close to those prescribed in the Standards and Guidelines of the European Network of Quality Assurance ENQA [4]. It is not surprising, since the Center for Quality Assurance in Higher Education of Lithuania is included into the European Quality Assurance Register. And this is possible only in strict compliance of EP evaluation criteria and procedures with ENQA Standards and Guidelines.

[6] *This approach resembles the approach taken in higher education system of Great Britain, where universities are guided by a document entitled Benchmark Statement, describing the framework requirements for whole areas of engineering education. Universities then develop learning outcomes for their EP on the basis of these documents.*

Conclusion

Review of accreditation of engineering educational programs in Lithuania shows that this system follow the requirements set out in the Bologna process. The system is essentially focused on the opinions and the role of all stakeholders of the educational process, and, as it was noted by the author, finds a good understanding of both teachers and students of Lithuanian universities. However, the system is very strict - the statistics presented in the article proves this fact. Probably it is quite obvious, given that the higher education system of the Republic of Lithuania pays close attention to education quality striving striving to become an equal partner in the European Higher Education Area.

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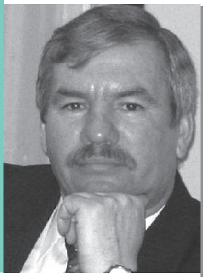
TRAINING AND QUALIFICATION OF RUSSIAN PROFESSIONAL ENGINEERS

Togliatti State University, Institute of Mechanical Engineering
V.V. Eltsov, A.V. Skripachev

Only professional engineers can provide modernization of the national economy. These engineers should possess not only high professional skills but also the initiative, creative approach to decision making and high responsibility for the results of their engineering activity. In order to train such graduates the university programs have not only to meet the requirements of the Federal State Educational Standards but also increase it significantly in the field of orientated development of the graduates'competences under conditions of systematic interaction with employers to implement training competence model for future engineers. The socio-professional accreditation of such an educational programme, which is carried out in accordance with worldwide criteria, gives a graduate an opportunity to be licensed as a Professional Engineer at National or European Engineer Certification Centers.

Key words: professional engineer, educational program, accreditation requirements, professional standard, curriculum, oriented development, certification.



V.V. Eltsov

A.V. Skripachev

What is a Professional Engineer?

To set up the discussion on the issues concerning professional engineer training and certification in Russia, it is essential to gain greater insight into the category of Professional Engineer, specifically to figure out what this concept means. In Soviet system of higher education, the graduates of technical institutions were awarded diplomas specifying their qualification as production engineer, design-engineer and mechanical engineer in any given industry. In other words, a soviet graduate was frequently termed by such slang expression of the time as "specialist with a diploma". In the meantime, the same graduates were categorized by manufacturing enterprises, which were the main 'consumers' of the soviet educational system, based on their level of knowledge and skills. At a later stage, they were qualified in accordance with their experience background and personal features; however, in most cases employee's qualification was strongly dependent on the presence of vacancies in the staffing pattern of an enterprise. Besides, some graduates were indeed engaged in so-called engineering work, i.e. design, construction and technology development, while the rest became the heads of manufacturing departments, engineering or economical services and even human resources department within two or three year period. As a rule, these engineers were to discharge carefully their typical duties in accordance with the job description or definite engineering task without considering the application of their ideas, as well as initiative and creative thinking. At the time the engineers were often called "performers" who were not encouraged to personal growth and showed no concern to the development of the company whose technical policy was restricted by definite ministerial special-purpose programs fulfilled through the strict obedience to the instructions of a chief engineer. It is obvious that such system, along with the absence of

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competition, could hardly contribute to developing creative potential not only of a particular engineer but also of the whole enterprise. What actually happens is that the absence of the possibility of making independent engineering decisions as well as lack of interest in creativity results significantly decreased engineers' motivation for self-development, which in its turn became the reason for further degradation of an "Engineer's Degree".

The development of private ownership was manifested with the establishment of numerous small and medium-sized enterprises which also manufactured technical products. The implementation of various small-scale and large-scale engineering projects, as well as open competition in goods-producing and service industries prompted a greater demand for highly-qualified engineers capable of not only handling any technological problem but also working independently in project implementation or as a part of a team and what is more important it is the ability to assume responsibility for the results of their engineering activity. It is just this capability of working autonomously or as a part of a team, taking responsibility for any technological decision with due regard to the most contemporary engineering studies and up-to-date information technologies that makes the difference between "Professional engineer" and "Engineer-performer". Ability to create new analysis-based solutions, strong interpersonal skills and initiative, self-development and personal capabilities that form a foundation for effective work are the main characteristics of an employee, awarded the degree of "Professional Engineer". The requirements for training of "Engineers with diploma" were categorized as follows: knowledge, skills and experience. Today, in order to figure out the requirements for "Professional engineer" training, it would be useful to refer them at least to those described by Benjamin Bloom in his work "Taxonomy of Educational Objectives: the Classification of Educational Goals" (1956):

- knowledge – define, identify, reproduce;
- comprehension – interpret, distinguish, extend, explain;
- application – operate, apply, implement, relate;
- analysis – differentiate, characterize, comply;
- synthesis – generate, create, compile, reconstruct;
- evaluation – recheck, relate, control, test.

Although the above-mentioned competences and skills do not completely describe the "competence model" of a "professional engineer", however it is obvious that they differ significantly from the training requirements that were imposed on "engineers with diploma" in higher technical establishments. Besides, a "professional engineer" differs from an "engineer with diploma" by the relevant working experience and certificates awarded by various public and administrative professional establishments to prove a high level of an engineer's knowledge and skills.

As we have outlined with some degree of certainty the subject of our research, it is time to examine the following question: how and where a "professional engineer" could be trained? How and where a "professional engineer" could be certified?

What is known about "professional engineer" training and certification?

It is known that since the inception of the Bologna Process (2003) and up to the present day, i.e. the State Law on Education adopted by the State Duma, the higher educational policy in Russia is focused on the integration of higher educational establishments into education world community. By introducing the two-level educational system (Bachelor's degree and Master's degree), the Government of the Russian Federation makes it possible to divide Russian graduates into two groups in accordance with the foreign education system seeking the recognition of Russian diplomas

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of higher professional education abroad. Without weighing in on the debate over the efficiency of such reforms and expending our time in sliding into reverie over Soviet higher educational system, we want to state that the employees in higher educational institutions and the leaders of engineering community should not only hold the current level of engineer training but also to improve it assuring the formation of the basic professional engineer's competences. Moreover, it is highly required to launch certification programs for engineers and as we are dealing with a "professional engineer" it is urgent to provide favorable conditions for encouraging the mobility of engineering graduates and professionals at international level.

It has long been known that there are various certification groups and associations for engineering education accreditation in European Union and the Washington Accord countries. Due to these professional certification groups, the certification process is accurately defined, the number of engineers is monitored and qualification requirements are constantly upgrading. The European Federation of National Engineering Association / Fédération Européenne d'Associations Nationales d'Ingénieurs that unites national engineering associations from 29 countries including Russia is one of the above-mentioned professional certification groups. In the United States, Accreditation Board for Engineering and Technology (ABET) is recognized as the worldwide leader in assuring quality and stimulating innovation in applied science, computing, engineering, and engineering technology education.

The European Network for Accreditation of Engineering Education (ENAEE) authorizes quality assurance and accreditation (engineering educational) agencies within the European Higher Education Area. Quality standards in engineering educational programs, which were developed by ENAEE the EUR-ACE Project, are universally acknowledged. The EUR-ACE standards being complied with the Standards and Guidelines for Quality Assurance for the Higher Education Area and developed by ENQA, are proved to be the standards for evaluating educational programs in the framework of the Bologna Process [1]. For registration as "European engineer", it is required to complete the educational program accredited in accordance with the EUR-ACE standards.

As for Togliatti State University, there are only three educational programs, i.e. Specialist degree programs in welding technology, mechanical engineering and industrial power supply, which have been accredited by RAEE in compliance with "EUR-ACE" international criteria. However, the transition to the two-level educational systems has prompted the necessity for a new accreditation of Bachelor's and Master's programs.

What problems should be solved in order to make a "professional engineer" training possible within Russian conditions?

The development of educational programs, both the Bachelor's and Master's degrees, is the first and the most important problem without considering business demand for such specialists. It can be explained by the fact that current educational program, on the one hand, could hardly comply with the suggested time limit and, on the other hand, does not correspond to the main purposes of an engineer training.

The Bachelor's and Master's program requirements presented in the 3rd generation of Russian State Educational Standards are fairly formal, while the suggested Bachelor's and Master's educational programs are just rough samples. Unfortunately, both mentioned documents could hardly be described as a conceptually new approach toward a "professional engineer" training. The structure and content of the 3rd generation of Russian State Educational Standards, concerning the Bachelor training degree, principally, did not change in any item, with the exception of the following fact – the term "classroom hours" was changed into "credits", while "knowledge, skills and experience" into "competences". Structure requirements to the basic education programs remain the same, i.e. it includes the same following subject-blocks: humanitarian and socio-economic, mathematic natural science, scientific and professional. In other words, the situation is as follows: the economic society parameters have sharply changed; the volume of different processing information has drastically increased; and the requirements to the education process results have also changed, while the higher professional education model for future graduates, as well as educational programs and teaching quality assessment are still the same within the previous framework.

In all fairness it has to be added that there are also positive changes concerning the development of new professional educational programs that have been recently taking place in Russian scientific community. For example, the "Methodological Guidelines" [2] on educational program development in accordance with the Federal State Education Standards has been published where the draft of the overall structure of new educational program has been figured out. The authors point out (See "Methodological Guidelines", Chapter 2) that "the curriculum content of compulsory subject-blocks in overall educational programs is only partially regulated by the legislation bodies". And further: "The overall higher professional educational program that is to comply with the Federal State Education Standards within a definite specialization is developed in response to a number of fundamental factors. First and foremost, it is the logics of competence approach which is applied as the basis of the Federal State Education Standards concerning higher professional educational program and the implementation of which involves not only preservation of the current module-based structure but also the development of student-centered, integrated and multidisciplinary educational setting". It is obvious that a competence model of a graduate elaborated not only in accordance with the Federal State Education Requirements but also and mainly in compliance with the professional standard should serve as the basis for educational program development. Indeed, the analysis of the suggested draft of the general educational program discussed in Chapters 2 and 3 has shown that the basic characteristics of a graduate's professional work are related to the professional standard. However, even here the correction "if such characteristics exist" is introduced. In our opinion, the elaboration of the competence model of a graduate based only on the requirements of the Federal Sate Education Standards without considering professional standard requirements will lead to the development of the certainly obsolete educational programs. To prove this point of view, one can consider the following example: United Aircraft Corporation developed its own professional standard for graduates of a number of Russian Aviation Institutes. However, all educational programs failed to provide the achievement of clearly stated outcomes [3]. Besides, the obligation to consider a professional standard while developing the general educational program within a definite specialization must optimize the interaction between higher education and business communities, which in turn will definitely contribute to the economic development of the country. The encouraging thing is that there are also some changes in a professional standard development within the automobile production and manufacturing. A number of seminars were organized and held in 2011 under the auspices of the Ministry of Industry and Trade. The representatives of higher education and business communities were involved in the discussion aimed to figure out standard requirements toward professional activity and engineer qualifications in Russian automobile production and manufacturing.

As for other accompanying documents of the general educational program, they are also undergoing some of the changes which, however, are deeply rooted into the content and structure of the previous educational programs. For example, a curriculum is suggested to be of two types. The first is competence-based curriculum which is focused on the correlation of all graduate professional requirements, i.e. competencies, with the courses and subjects being taught in a definite time sequence. In other words, competence-based curriculum (definite disciplines, courses, vacation training) is focused on the outcomes (competencies) that are linked to workforce needs, as defined by employers and the profession. This type of curriculum forms an innovative statement in higher professional education in that it allows a competence model to be integrated into education even better than before. The second type is a traditional time-based curriculum within which training is understood as a series of subject-block rotation (humanitarian, social and economic, mathematical, professional blocks as well as natural science) with the idea that a student acquires this or that competency from each one at a different time period.

Unfortunately, the overall structure of the proposed educational program draft developed in compliance with the Federal State Education Standards is divided into paragraphs (See "criteria" as State Accreditation of general educational program is carried out in accordance with criteria) which, though resembling the international criteria developed within EUR-ACE Project, are significantly different from them.

In the meantime, there are definite criteria and technologies being well-known both in Europe, and Russia which are intended for the development of educational programs and curricula considering the needs of professional community (competence model), learning result assessment and training arrangement. These criteria have been developed by Russian Association for Engineering Education (RAEE) and they can be easily correlated with the accreditation program requirements within ENAEE framework standards (ABET Criteria 2000).

We intentionally provide here again the accreditation criteria developed for the quality assessment of educational programs and a well-known dual-mode process of educational program development as it is just these documents a general educational program should comply with (Fig.1) [4].

Notes:

1 – requirements set by the parties concerned;

2 – developing objectives of educational program;

3 – insurance of target attainment;

4 – determination of learning objectives and attainment targets;

5 – developing implementation strategy for learning target attainment;

6 – developing a strategy for learning outcome assessment;

7 –determination of result achievement indicators;

8 – learning process development.

More detailed step-by-step procedure of a new educational program design in accordance with RAEE criteria and various stages of development, i.e. organizational, preliminary and basic, is described in the works of A.I. Chuchalin and V.V. Eltsov [4,5].

A further variant of engineering education program design (Fig.2) which also considers FEANI –ENAEE criteria and corresponds to the above-mentioned scheme is discussed in the work of E.D. Alisultanova [6].

Both ABET dual-mode model and the process of educational program development presented in Fig 2 involve almost the same stages with only differences occurring in titles. For example, the 4th stage of both mentioned models implies the development of a graduate's competence model. The 8th (Fig. 1) and the 7th (Fig.2) stages are considered to be the most important in the development of educational program within higher professional establishment framework. The 8th stage implies the

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Fig.1. Fundamentals of New Educational Program Development Based on ABET Dual-Mode process (model).

1 – educational program objectives;
2 – educational program content;
3 – students and learning process;
4 – higher-education teaching personnel;
5 – focus on job performance;
6 – material and technical facilities;
7 – information and analytical support;
8 – finance and management;
9 – alumni.

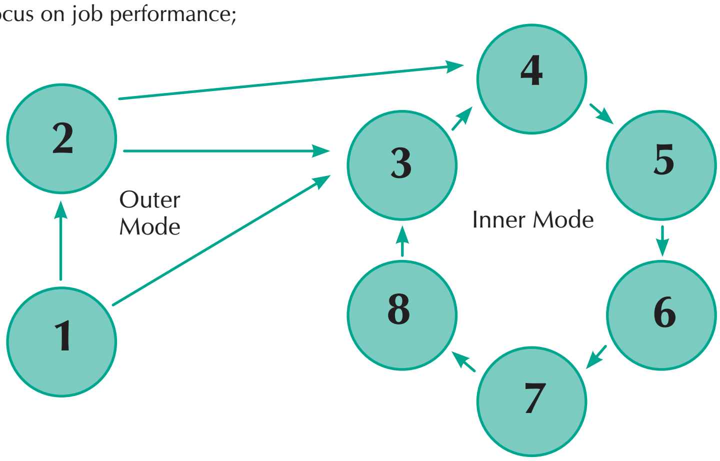
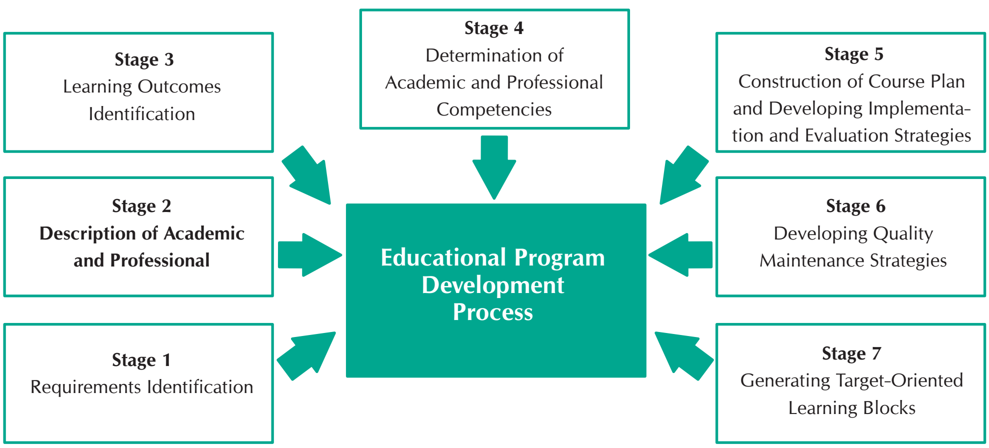


Fig.2. New Educational Program Development Process



arrangement of a learning environment in such a way that curriculum development becomes the most essential step, while the 7th stage of the second model is directly concerned with generating target-oriented learning blocks.

The achievement of this or those learning outcomes, which quality directly influences the formation of professional engineer's competencies, depends to a large extent on the curriculum structure and content. Therefore, the main task in arranging new educational environment is to develop such curricula or learning plans with the help of which it would be possible to create educational experiences in a variety of formats and tailored for the specific competency of a graduate.

However, this is far from being the case, as even well-distinguished and highly-regarded scholars still recommend in their works to apply the traditional time-based curriculum where subjects being taught are categorized as humanitarian, social and economic, scientific, mathematical or professional blocks. The subjects are taught in a definite time sequence as before without considering the formation of this or that graduate's competency. It can be stated that a new type of curriculum, i.e. competence-based curriculum, should be recommended for so-called "advanced" university clusters [2].

Above all, the curriculum itself is developed not on the basis of a competence model elaborated in compliance with employer's requirements but as a series of subjects with some being defined as electives to create an allusion of target-oriented learning. The most forward-minded heads of the departments who are also one of the educational program developers try to introduce some definite subjects or courses into the curriculum, which would, in their opinion (influenced or not by an employer's needs), contribute to the development of a stated or required competency. All this could hardly contribute to the achievement of the main objective, i.e. a professional engineer training. It can be explained by the following reasons:

1. Curriculum is not developed in accordance with a graduate's competence model designed in compliance with employer's professional requirements;
2. Curriculum structure does not contribute to the development of the required competencies.

In order to move from the traditional time-based education toward a competency-based one aimed at achieving clearly stated competencies, a curriculum structure should include various learning units and modules with each module being linked to a definite competency acquisition within a graduate's competence model. A module is a learning segment with a specified educational or training purpose including a set of courses or subjects aimed at achieving required competencies. In this case, it is possible to develop learning modules not only based on already existing subjects but also involving absolutely new ones which have never been taught before but very essential for a successful competence model implementation. In addition to, once the "database of learning modules" is created, it is possible to modify learning process depending on the required outcomes. Besides, it should be noted that as almost all foreign universities apply module-based curricula, a certain degree of conformity and harmonization can be observed between Russian and foreign educational programs. The example of module-based curriculum development within a definite Bachelor's degree program is provided in our works "Bachelor's Educational Program Development Process Based on Competency-Based Approach" [7] and "Engineering Educational Program Development Process for Innovation-Oriented Specialists" [8].

The second problem to be solved within a professional engineer training is the problem of educational program accreditation.

Within the framework of higher professional education, state accreditation is closely connected with the State Educational Standards of Higher Professional Education in the Russian Federation, which prescribe the minimum requirements concerning curriculum content and graduates' training level within a definite program or degree. As for Europe, there are no any State Educational Standards, except for Germany. Therefore, evaluation of university performance in Russia significantly differs from that abroad. In Russia, State Educational Standards serve as the basis for outlining general educational environment and facilitating student academic mobility. As Russian Higher Professional Educational System is focused on the to integration to the All-European higher education environment, State Educational Standards of Higher Professional Education must be considered as just so-called "frames" within which universities can independently develop educational programs

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depending on the peculiarities of the region. Besides, these "frames" must not set the limits in correlation of Russian and foreign higher education curricula. Therefore, both Russian and European accreditation systems of engineering educational programs must be accorded with the national accreditation agencies working within concerted standards. It is obvious that the criteria and methods applied in these accreditation agencies must be set out within "EUR-ACE" framework. In this case, if accreditation is carried out by one of the EUR-ACE-authorized agencies, it can be qualified as European "EUR-ACE" accreditation. Professional accreditation in engineering education offered by RAEE Accreditation Center is the most prominent example.

The third problem concerns the qualifications of engineering graduates within first cycle and second cycle degrees.

This problem is critical not only for Russian Higher Professional Education but also for the representatives of engineering companies, i.e. any employer who is a potential "consumer" of a graduate. It is obvious that the problem could be solved only by a concerted effort of academic and professional communities. Detailed requirements for various state and private businesses have been set out in the Recommendation to the Parliament Proceedings "Contemporary Engineering Education as an Integral Part of Technological Modernization of Russia" held in the Committee of the Council of the Russian Federation on 13th May, 2010. The main issue of the proceedings was as follows: "It is necessary to discuss with the representatives of the professional communities the possibility of establishing regional centers providing professional qualification certification". As the result, Russian Center of Certification and Registration of APEC Professional Engineers was established in 2010 upon an initiative of Russian Union of Scientific and Engineering Organizations and RAEE agreement.

As a response to these events, a series of seminars and conferences uniting academic representatives and engineers of the above-mentioned automobile production and manufacturing was organized by the Ministry of Industry and Trade in 2011. We cannot but hope that the same changes will take place in other industries, which in turn will contribute to the development of competence models (professional standards) within the two-level education system and prompt the Ministry of Education and Science of the Russian Federation to develop new educational standards considering Parliament proceedings and competence models (Fig.3).

Special attention should be given to the fact that the Recommendations to the Parliament Proceedings were prepared in May, 2012. Therefore, we are dealing not with the 3rd generation of Russian State Educational Standards, but with the standards "...aimed at facilitating graduate job performance...".

Thus, it can be stated that the problem of engineering graduate qualification within first cycle and second cycle degrees, as well as acquiring qualifications of "Professional Engineer" or "European Engineer" is still to be solved. In the meantime, this problem is already a stumble block in the modernization of Russia's economy, announced by the President and the Government of the Russian Federation. There are already many examples of this. Many foreign companies which are involved in the implementation of any technical project in Russia have no rights in accordance with the regulative documents to recruit Russian engineers to the leading positions as they have no qualification of a "Professional Engineer". To solve the problem, the companies have to invite European engineers for extra charge. Such situation which can be termed as "second-rate" could hardly contribute to the development of either Russia's economy, or engineering community.

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Conclusions.

1. Training and Qualification of Russian Professional Engineer is an integral part of the modernization of Russia's economy.

2. The current engineering educational programs, including those developed in accordance with the 3rd generation of Russian State Educational Standards do not completely correspond to the quality requirements of "Professional Engineer" training.

3. State accreditation system does not provide Russian engineers with the required conditions to be qualified as "European Engineer" (Professional Engineer").

4. New educational program developed in accordance with international "EUR-ACE" quality criteria and including outcomes-oriented and module-based curriculum with further accreditation by the public professional agency is the main condition for Russian engineering graduates being qualified as a "Professional Engineer" ("European Engineer").

Рис. 3. Text passage from recommendations of parliament proceedings (Council of the Russian Federation in Education and Science

3. Министерству образования и науки Российской Федерации:

1. Обеспечить разработку и введение в действие федеральных государственных образовательных стандартов профессионального образования, ориентированных на формирование готовности выпускника к профессиональной деятельности и обеспечивающих повышение свободы образовательного учреждения в формировании образовательных программ с учетом запроса реального сектора экономики.

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INTERNAL EDUCATION QUALITY CONTROL IN UNIVERSITY

Eastern-Kazakhstan State Technological University named after D. Serikbayev
A.K. Tomilin

The conceptual model of internal monitoring for educational process based on the principles of IOS international standards has been suggested. It is shown that systematic approach allows for appropriate conclusion about competence of every teacher, reliable evaluation of his (her) work quality. The experience accumulated in EKSTU named after D. Serikbayev is described.

Key words: *ISO standards, quality management system, the principles of QMS, teacher testing, web-technologies.*

А.К. Томилин

Usually, the heads of universities pay special attention to the external estimates of their institutions. Certification, institutional accreditation, academic rating positions – all these, undoubtedly, influence the image of university and its competitive performance. But is university management interested in objective internal evaluation of educational process quality? The management style and methods essentially depend on the answer to this question. Only in case of positive reply it is possible to apply an up-to-date management technique accepted in the international quality standards of IOS 9001 series [1-2]. In the opposite case, one cannot provide the principles of quality management system (QMS) as the first of them is not realized – the leading role of management.

If a head sets a clear goal to his team – to provide the quality of educational services – he has to realize the subsequent QMS principles. One should start with arrangement of the major processes, for universities it is, first of all, educational process. The process development starts with determination of its «inputs»-«outputs» and establishment of placement and final test methods. Not of less importance is quality management in the course of process after each procedure, i.e. current internal quality control. If, for instance, we consider the process of conveyor manufacture, all facts mentioned before are easy to present: a work piece is delivered to the conveyor (input), and then it goes through several processing stages (procedures), from conveyor a final product is given off (output). The quality control is performed at each stage by means of measurements, i.e. objectively. One can always define who and at what stage made a mistake.

In the educational process everything is significantly more complicated. To evaluate and measure the quality of each teacher's work is not simple. Usually, open classes, classes exchange visits, checking of methodical support etc. are in practice. In this case a teacher's professional

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competence is evaluated occasionally and subjectively. The problem of evaluation reliability and self-evaluation for teachers' work is being discussed, for example, in the article [3]. The authors of the article have fairly noted that this problem is difficult to solve and has no simple solutions.

One often tries to correlate teacher's work quality with the rate of students' achievements. Does such an approach always show objective estimation? It should be taken into consideration that students' progress does not always serve as a criterion of educational process quality in general and the work of individual teacher, in particular. In university education there has long been the situation in which all participants of educational process (lecturers, students, and management) are interested in maximal increase of this indicator. A lecturer, on the one hand, provides the services, but, on the other hand, controls their quality. As such an approach one cannot exclude the administrative regulation of progress indicators; moreover, there appears the possibility of corruption practices.

What methods can be used to control the quality of educational process? How is it possible to evaluate every lecturer's job objectively and reliably? Without solving these questions one cannot take management decisions relying on facts as it is required by the next QMS principle. There arises the problem of educational process monitoring organization.

In spite of the priority of the final results in education, the essential point in the conditions of credit evaluation is current control of students' knowledge in the course of academic period. According to credit educational approach, the specific weight of current control in the discipline final evaluation is not less than 60%. It is always performed by a lecturer teaching this course. In this case subjective evaluation is not, of course, excluded. It is possible for a lecturer to evaluate at two current control points at his own discretion instead of student's achievement systematic evaluation during the term.

One can improve this undesirable situation when fulfilling two conditions: first, clear definition of control methods in the curriculum at every week, second, introduction of computer program for every-week students' absence and progress registration. Similar computer program is applied in EKSTU named after D. Serikbayev and is one of the resources of the university educational portal SPORTAL (http://www.do.ektu.kz/doektu/Default.aspx). The access for data input on students' progress and absence is strictly limited. The lecturers use personal logins and passwords for this purpose. At the end of every academic week the access is closed. In some exceptional cases (illness, student's absence for other excusing reasons) the data are entered later by the assent of the head of Academic Service Department.

It should be underlined one more time that current students' knowledge evaluation is associated with subjective factor. Therefore, final control is necessary to make maximally objective and independent. All over the world this problem is solved by application of tests in the final evaluation. The bases for test pedagogical diagnostics have been thoroughly developed and successfully applied in the world [4].

Testing knowledge control possesses both decisive advantages and some disadvantages. They often say that at this control method there is no oral communication between a student and a lecturer, there are problems with checking logical discipline connections, there is no opportunity to evaluate the skills of written rendering of knowledge. It is really so, as tests are not intended for this. Hence, in current knowledge control it is necessary to use such methods as interview, written theory checking, and students' reports at seminars, presentations of laboratory work results etc. In other words, current control methods are to enlarge the methods used in final evaluation. Unfortunately, sometimes a lecturer uses only tests during term trying to prepare students for test evaluation. In this case the systematic proficiency in the discipline is not formed; students' creative abilities are not developed. One of organizational-academic problems of any department consists in providing the conditions excluding such an approach.

A real advantage of knowledge testing control is its objectiveness and independence. But its application is accompanied with obligatory fulfillment of a number of conditions which will be spoken about below. If all these conditions are met, the data on the educational process quality will be objective enough and, hence, they may be used in analysis. For instance, head of department and lecturers have possibility to compare the average current progress with average exam evaluation on a discipline in a definite students' group. Similar analysis can be performed with respect to every individual lecturer and make conclusion on the results of his (her) job. On the basis of such analysis the management of any level (head of department, dean) can take necessary decisions of academic and organizational character.

Let's consider one more important question. Who has to arrange and perform the final evaluation of students' knowledge? In many universities testing departments are included in registration office which, in its turn, is reported to vice-rector of academic affairs. In this case there is no complete separation of authorities concerned with educational services and their control and, hence, there is a possibility to regulate the students' progress administratively. Usually, it is reflected in refusal (direct or indirect) from development and application of objective methods and tools for students' knowledge control. In our opinion, to exclude such a case is possible by means of arrangement of maximum independent testing centre (department). In EKSTU named after D. Serikbayev, for example, testing department is included in Quality Department, director of which is directly reported to the rector. The experience has shown the advisability of such authority separation. In some western countries students' progress monitoring is performed by outside agencies not included in university structure.

To perform testing in computer form it is necessary to arrange a number of activities including:

- academic work in test development,
- organizational activity, development of reliable software.

It requires involvement of lecturers and workers from all departments and offices in these activities. Development of test resources for final control is an important part of department academic work. The head of the department needs to focus the lecturer' efforts on this activity, distribute test development responsibilities among lecturers, assist lecturers methodically, and stimulate colleagues for enhancement of testing material quality. Reliable information about the results of learning process depends directly on the quality of control-measuring materials.

Testing department arranges and regulates formation of test resources meeting didactic requirements. It organizes training seminars for those who compose and examine tests. At those seminars the major attention is paid to methods of test development, principles of test composition, typical mistakes in testing tasks made by designers, training of specialists. Before examination time trial testing is performed to adapt first-year students for this method. After examination time the analysis and generalization of statistical data is made.

Development of reliable software and technical support of testing procedure are rested on Information Technology Center of EKSTU. Special

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software for computer testing «Test Master» was developed in it. It allows for standardization of test resources. The given testing program forms a test for every student consisting of tasks from all courses included, according to the syllabus, in the discipline testing resource. Tasks in every part of test resources have the same complexity level, therefore, all designed variants of tasks are the same in complexity.

«Test Master» interface contains information on student's identification as well as all necessary functions including question numbering and the remaining exam time. In the course of exam a student has a possibility to lodge an appeal using in-built function «appellation». Appellation committee has to dispose appellation in electronic form that permits them to computerize the procedure and increase its efficiency.

Application of modern web-techniques contributes to reduce the cases of corruption, guarantee of identification and information monitoring, its reliability, objectivity and is an efficient tool in quality management of educational activity.

Computer testing in EKSEU is regulated by documentary procedure «final control and evaluation of students' knowledge» https://www.do.ektu.kz/laws/smk/10_DP_EKSTU_8_2_4_I_2009.pdf).

In the document the academic and engineering requirements for test resources are defined, the expertise order is developed and the computer testing procedure is described. Besides, the procedures of appellation and correction are applied, i.e. correction procedure of test resources is established to improve their efficiency, the order of academic failure disposition is stated.

Admission to exam on every discipline is given automatically only in case of positive average admissible rating score – 50 points and higher. Students' admission to examination from the dean office is given by the data input in SPORTAL.

After the examinations the test designers, department heads, deans receive the following statistical information which is used for permanent improvement of test materials:

- average exam points (on 100-point scale) in every test database (the base is considered to be appropriate if it is in the range from 60 to 90 points),
- the number of students passing exam in the given testing database,
- mean time spent for test performance on the discipline (the optimal indicator is from 60 to 90% of maximum time required for test performance),
- information about every question in the test base with the number of correct and incorrect answers to it,
- the relationship of average rating score and average exam points in every academic group on every studied discipline is also taken into account.

What conclusions should be made on the basis of the data analysis? The answer seems to be unexpected: one can evaluate objectively lecturers' academic qualification and proficiency, who teaches the given course and is a developer of the test materials. Indeed, qualified, competent lecturer is able to work out the complexity level of tests and time required for their performance adequately. In addition, at professional approach to evaluation of students' current progress (admission rating), on the one hand, and use of qualitative test materials, on the other hand, there is no significant divergence between the average rating score and average exam points in the given academic group on studied discipline. Hence, there appears the possibility to realize the QMS principle mentioned above: when taking decision one should rely on facts. The evaluation obtained as a result of such an analysis can be used in determination of every lecturer's rating. One can make a definite conclusion about conditions of academic-organizational work at a definite department.

In order to increase the quality of test resources the documentary procedure «certification of electronic test bases» (https://www.do.ektu.kz/laws/ smk/16_DP_EKSTU_8_2_4_I_2009. pdf) was developed in EKSTU. Here the requirements for test base and its estimation criteria are determined.

Students and their parents have possibility to get information about academic achievements via terminals located in academic buildings or Internet (http://www.do.ektu.kz/doektu/Default. aspx?lang=ru). Electronic records allow for efficient result analysis of not only final (intermediate) evaluation but also current (rating) control. In large university it can give opportunity to monitor educational process efficiently. The system of quality management of any university is incomplete and inefficient if there are no tools for monitoring of basic process – educational one - using computer technologies in it.

Thus, efficient internal quality control in university is possible only in the condition of systematic approach to management allowing for solution of the complex problem.

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TECHNICAL UNIVERSITY GRADUATE EMPLOYMENT RATE

Moscow State Technical Institute of Radio-engineering, Electronics and Automation, MSTU, REEA
M.V. Pokrovskaya, A.V. Sidorin

Higher institution efficiency is determined by employability and education quality of the institution itself, whereas efficiency criteria are based on the compliance of graduate competencies to employers' requirements, as well as their labour market competitivity. Development strategy of this or that institution, as well as its policy, target and objectives in education, research and innovation significantly depends on future graduate employability and his or her professional competitivity. This fact highlights the definition of graduate employability as education quality assessment criterion and as an indicator of labour market demand. Besides, graduate employability is also an indicator of employer satisfaction and continuous improvement of graduate competences which, in its turn witnesses the attractiveness of this or that institution.

Key words: *employability, competitiveness ability, competences, professional competence certification, quality man.*

М.В. Покровская

А.В. Сидорин

The issue today is the fact that there is no unified comprehensive professional assessment system and distinct assessment criteria in evaluating the graduates' professional and overall cultural competencies within the framework of the existing professional education quality assessment. This involves the assessment of not only the formation of these competencies, but also the further professional life performance of the graduate. An overview of the traditional approaches in the assessment system and evaluation of graduate's competencies has been forwarded and highlighted in the Federal Standards (Federal Education Standards) and include the following items: incorporation of employment requirements, in-depth integration of professional standards, introduction into professional associations, expansion of international co-operation and breakthrough into the International Education Space under the Bologna process.

Development and implementation of quality management system and the independent public-professional accreditation of education programs established the groundwork for the updating of the independent education quality system and the furthering of graduate competencies throughout all the stages of his/ her professional life.

The most effective solution in the provision and independent evaluation of the combined graduate and business (enterprise) specialist competencies respective to employer's requirements involves the development and promotion of an independent evaluation system and accreditation of professional engineering qualifications. Another important problem is the evaluation of such factors as the employability of technical university graduates, their labor market competitivity, as well as, the relevance of this or that priority qualification area, profile or specialist training field. This, in its turn, would enable the university, faculty or even profile department to reorganize its development strategy, policy, targets and objectives in preference to the implementation of on-demand education programs and graduation training in competitivity profiles. This problem can be successfully solved through an independent evaluation system and accreditation of professional engineering qualifications, including the establishment of an expert-methodology center network, embracing integrated concepts, rules and procedures, and complex regulatory-procedural documents. The activities of this independent reliable evaluation system for specialist competencies require the solution of a set of problems, including concept and principle development, organizational system structure, regulatory-methodical provision, infrastructure development, expert- methodology center network, training expert-specialists and the activity system organization itself with the involvement of enterprise- employers and professional associations [1,2]. The key area of activity – efficiency evaluation of all the activity system profiles, and the result of this integrated activity- evaluation of the employability and competitivity of graduates and enterprise specialists, as well as, skills profile and available university professional training, which, in its turn, are the significant education quality indexes of any university, faculty or department activity.

Due to labour market competitivity and employer requirements the graduates and enterprise specialists should possess a set of competencies, including knowledge, learning skills and abilities and definite personal social competencies (Fig.1).

Every participant in the education process and interested parties in developing the graduate competencies is different. At the elementary and secondary education levels personal and social qualities are introduced and developed, and eventually shape into competencies. Education institution (EI), i.e. university, develops and shapes combined cultural and professional competencies, social and personal qualities of the graduates. Under conditions of production activities the professional competencies are not only introduced, but also developed and enforced to further such abilities as team commitment, succeed corporate culture, social and personal responsibility [3].

Graduate's employability should be evaluated according to four index categories:

- objective indexes, determined by the specific requirements to the profession, employer requirements, labour market;
- personal (subjective) indexes, related to on specific graduate;
- external and internal social-economic factors;
- political conditions.

Basic qualities and competencies shaping during the education- instructional process including enterprise- employer requirements:

- skills in sophisticated world-practice technology;
- knowledge of sophisticated domestic and foreign equipment – technological, monitoring and experimental;
- knowledge of domestic and foreign reference documents (RD), standardization principles and management methods;
- skills in modern management methods, including management qualities, management resources, innovative and production management and personnel management;
- knowledge of corporate culture principles, responsibility and team commitment;
- personal and social responsibility;
- high moral standards;

- creativity, leadership and learning abilities;
- foreign language skills;
- skills in modern IT;
- open-mindedness, high cultural level;
- adaptability and tolerance;
- motivation.

Integrated index evaluates the overall employability indexes [4].

Higher graduate employability Kc, in comparison to those of graduates and specialists of the same profession (qualification, profile, specialization field) is a ratio of specialist competency level relevant to labour market requirements/ employer requirements (Pc), salary (Zc) and education expenses (Rc):

$$K_c = \frac{P_c \times Z_c}{R_c} \qquad (1)$$

Specialist competency level relevant to requirements is the value ratio of graduate employability \ enterprise specialist index sum to corresponding index values, required by the employers:

$$P_c = \frac{\sum_{1}^{n} k_{ci}}{\sum_{1}^{m} k_{rm}} \qquad (2)$$

where, k_{ci} – value of one of the n indexes, describing the specialist –graduate competency,which is normalized to its highest possible value-meaning;

k_{rm} – value of one m specialist competency index as employer or labour market requirements, normalized to its maximum possible value-meaning.

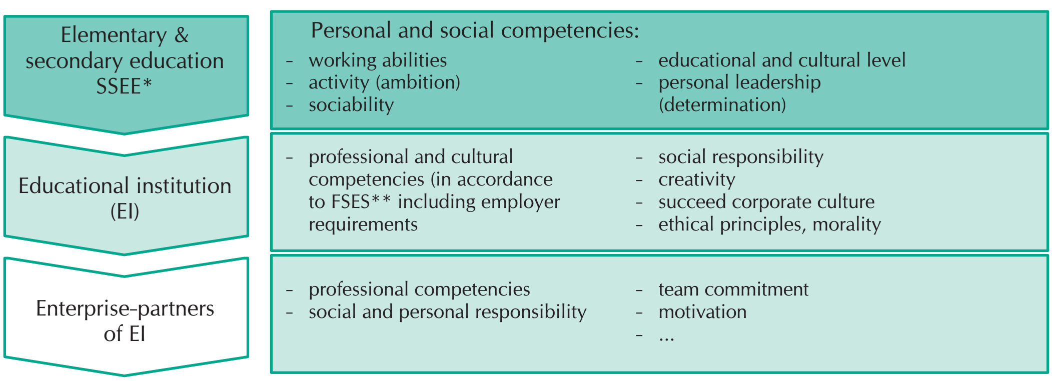
Graduate employability within the labour market K_{pc} is determined by objective indexes- profession competitivity, qualification (area, training profile), socio-economic factors and political conditions, within a profession area- all professional competencies, social and subjective, personal qualities of the specialist:

$$K_{pc} = K_n \frac{P_c \times Z_c}{R_c} \qquad (3)$$

Higher profession competitivity in comparison to other professions is the ratio of the specialist competitivity of one given profession relevant to the labour market or profession rating (Pп), averaged salary of this profession (Zc) and education expenses (Rc):

$$K_n = \frac{P_n \times Z_n}{R_c} \qquad (4)$$

Fig. 1 Function and role of participants in the development process of graduate competencies



** Specialized Secondary Educational Establishment*
*** Federal State Education Standards*

Objective indexes of specialist competitivity:

- employability and occupation prestige;
- training (education) quality, professionalism;
- competitivity (prestige) of the educational institution;

Subjective indexes of specialist competitivity:

- professionalism (education quality, training);
- personal qualities;
- social qualities.

Analytical evaluation of employability through ratios (1)-(4) in scaling (rating) and qualimetric approaches for competitivity evaluation indexes provides an effective process in shaping graduate competencies of educational institutions and enterprise specialists at different stages of their professional activity..

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STATISTICAL APPROACHES TO EDUCATIONAL PROGRAM QUALITY ASSESSMENT

National Research University of Electronic Technology
M.V. Akulenok, N.M. Larionov, O.S. Shikula

This article is devoted to the development of quality assessment techniques for educational programs involving the individual results of graduate learning outcomes. This statistical approach characterizing the quality of educational programs and denoting learning results as a system introduces not only an entropic indicator as quality indicator of educational program as a whole, but also as a level indicator of discrepancy in the system itself. The statistical approach was examined. The sources of the internal and external validity are shown.

Key words: *competency model, evaluation of the competency level, educational program quality, statistical approach.*

M.V. Akulenok

N.M. Larionov

O.S. Shikula

The implementation of Bologna process in Russia, representing some major changes in educational paradigm and shift towards outcomes-based or competency-based approaches has significantly influenced the basic methods of educational program (EP) development. Being urged by the adoption of the 3rd generation of Russian State Educational Standards, the application of professional competency model developed alongside with the educational program identifies the need to elaborate appropriate methods for competency level evaluation. The proposed control system enabling the faculty to identify the intended and actual outcomes of a learning experience is an essential condition for effective educational program management and fulfillment of Federal Education Standards requirements in terms of annual renovation of educational programs. The results of such evaluation experience could be applied not only for the analysis aimed at identifying the shortcomings of an educational program but also in the adoption of various managerial decisions.

One of the basic training objectives of engineering education is to prepare highly-qualified, knowledgeable, competitive and socially conscious engineers, who are able to perform qualified jobs within creative and science absorbing industries. Quality assessment of any educational program must be based on the evaluation of learning outcomes of each graduate. In fact, the quality and competitiveness of any educational program are defined by the quality and competitiveness of a graduate training.

In accordance with the last amendment of Federal Sate Educational Standards, learning outcomes are formulated at the stage of educational program development in terms of competencies (Fig.1). Therefore, the evaluation of the results or competencies being attained should be carried out at the same way [1-2]. From this point of view, the development of appropriate competency level evaluation methods

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Fig.1. Competencies and Bachelor's Curriculum (221400 "Quality Management") Correlation Sample

Discipline Codes	General Cultural Competencies (GCC)																
	GCC-1	GCC-2	GCC-3	GCC-4	GCC-5	GCC-6	GCC-7	GCC-8	GCC-9	GCC-10	GCC-11	GCC-12	GCC-13	GCC-14	GCC-15	GCC-16	GCC-17
B.1.1	■	■				■		■		■	■			■			■
B.1.2	■	■				■									■		
B.1.3		■				■											
B.1.4	■	■		■		■		■	■							■	
B.1.5	■	■		■		■		■	■							■	
B.1.6	■	■	■			■										■	
B.1.7	■	■	■	■	■	■			■	■	■			■			
B.1.8	■	■	■	■	■	■			■	■							
B.1.9	■	■	■	■	■	■				■							
B.1.10	■	■				■						■	■	■			
B.1.11	■	■	■	■	■	■	■			■		■	■		■		■
B.1.12	■	■	■	■	■	■	■	■	■	■		■		■			
B.1.13	■	■	■	■	■	■	■			■		■	■		■		■
B.1.14	■	■	■	■	■	■	■	■	■	■		■		■			

is an essential condition for successful implementation of 3rd generation educational programs. It is impossible to apply competency-based approach efficiently without the development of a thorough competency assessment framework.

Basic requirements for learning outcomes evaluation are as follows: reliability and objectivity; correspondence and validity; unambiguity and efficiency; comparability and timeliness. Besides, the accuracy of individual learning outcomes evaluation is a necessary condition for accurate assessment of the educational program as a whole. The proposed control system should not contradict the learning process itself, while the expenditures for its development and implementation should not exceed the value of the obtained results. One of the important characteristics of the system concerned is the possibility of visual presentation, which makes it more convenient to analyze, compare and correlate the results.

The analysis of the content and inherent characteristics of the competencies shows that, in general terms, a competency consists of three main components:

- cognitive - connected with knowledge and knowledge acquisition;
- integral-pragmatic – defines the process of skill formation based on the obtained knowledge and ability to transfer skills and knowledge to a variety of sign system allowing a graduate to adapt to new situations and professional settings;
- personalized – connected with personal value system which can influence significantly competency development.

The cognitive component defines the knowledge and intelligence level of a graduate including his/her creativity grade. It is closely connected with theoretical and methodological bases of the subject concerned and identifies whether a graduate is ready for professional activity from the point of scientific and vocational skills.

The integral-pragmatic component underlines the ability of a graduate to apply the obtained knowledge not only in the fields closely connected with his/her profession, but also in so-called "inter-subject zones" or even absolutely new ambiguous settings. The component defines the capability of a student to apply the lessons learned in his/her job performance.

The personalized component is reported to be the most essential and systemically important as it reveals the attitude of a graduate toward his/her professional activity. It significantly influences the dynamics of competency development. Therefore, considering the fact that the basic characteristic of a competency is that it must be always personally recognized as an own experience embodied into personal attributes and system of values, skills and knowledge, it is possible to assume that this component should be the subject of extensive research to solve the problems of competency level evaluation.

Russian and most foreign scholars believe that competencies are dynamic as they are not absolutely static units in human personality and can be characterized in terms of dynamic capacity, i.e. the capability of improving or disappearing due to the absence of motivation. Therefore, it is obvious that such terms as competency level and evaluation can be reasonably applied.

To develop a competency means to obtain the vision of what constitutes the specific knowledge, skills and appropriate value system required for a definite performance, searching for new solutions and ways out in absolutely unfamiliar settings. As a competency level is a rather latent and hidden parameter which cannot be immediately measured, probability approaches should be applied. The examples of application of probability approaches for competency level evaluation and description of personal characteristics influencing the competencies are provided in the works by A.A. Maslak [2] and I.N. Eliseev [3].

Whatever grading scale is applied for individual outcomes evaluation (five-point scale or 100-point scale), probability or statistical approaches allow us to obtain integral estimation of the learning outcomes of all graduates (according to each competency concerned) not only in terms of average score but also as dispersion value. Being a system of the elements including knowledge, skills and experience, a competency that should have been acquired and developed by the end of the education program is assumed to be reflected throughout the whole education period in terms of statistical value. i.e. entropy. Entropy is calculated based on the data of dispersion value of individual grades:

$$S = \ln\sigma^2 ,$$

where S – entropy, σ^2 – total dispersion.

This index identifies the influence of various factors on the learning outcomes. Besides, being a measure of the "disorder" of system elements, entropy is definitely connected with the level of possible discrepancies in a system (Fig.2). Herewith, minimal entropy corresponds to a minimum level of disorder and discrepancies (N) in a system. It makes possible to compare different educational programs, evaluate the dynamics of training quality.

Based on the fact that personalized and cognitive components are reflected in current and interim grades or attestation as well as the integral-pragmatic component of a competency is developed up to the end of education and reflected in final grades it is possible to propose the statistical approach as the basic method for educational program quality assessment considering, as well, competency level evaluation. It includes:

1. Consideration of the learning outcomes attained by a student at all stages of attestation within all

disciplines being taught in a definite time sequence in accordance with the corresponding weighting coefficients required for competency level evaluation (Fig.1).

2. Consideration of all individual learning outcomes of a graduate in diagnostic testing.

3. Holding the assessment results in database or university data system.

4. Consideration of the final grades including the evaluation provided by a scientific advisor, reviewer and members of the State Attestation Commission.

5. Calculation of integral competency level index based on the above-mentioned procedures, graphing of individual learning outcomes and comparative analysis of learning outcomes of different students (Fig.3).

6. Dispersion analysis of competency level evaluation, calculation of entropy index S.

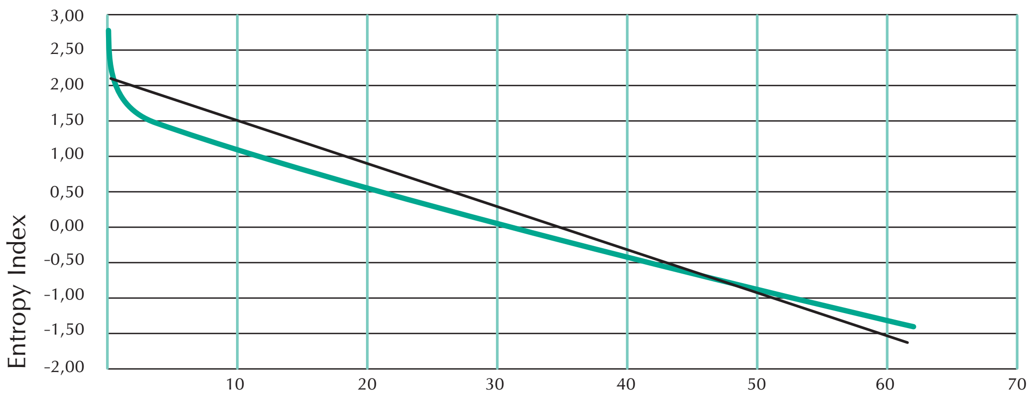
The current control systems which are widely applied in higher educational institutions for the assessment of students' academic performance include the above-mentioned 1-4 stages and in most cases to hold the assessment results, university database is commonly used. Based on the data accumulated in the university database, it is possible to plot a diagram of individual student results automatically as well as to calculate integral indexes, define dispersion value and calculate entropy index characterizing the quality of an educational program.

It is difficult to overestimate the significance of the final assessment which is usually manifested in the fulfillment of a design project, i.e. the simulation of actual job performance, expert review, opinion of the scientific advisor and the members of the State Attestation Commission. Besides, the development of a definite final attestation procedure will require eloborating a well-grounded list of competencies to be evaluated at the end of the education [4].

The approbation of the discussed approach carried out in National Research University of Electronic Technology within the framework of the 2nd generation educational programs ("Quality Management" educational program) as well as the comparative analysis of statistical evaluation of graduates' academic performance and students' test results for educational program quality assessment have obviously proved the high objectivity of the proposed quality assessment system of educational programs.

The validity of system discussed is provided, on the one hand, by the thorough investigation of the object concerned (student's learning outcomes evaluation is carried out at different

Fig.2.Dependence of Entropy and Dispersion Indexes



stages of current and interim attestation with all results being held in university database) and, on the other hand, by the internal relations (while evaluating competency level, it is essential to consider the learning results within those disciplines that directly contribute to the development the competency being analyzed (Fig.1).

The advantages of the proposed approach are the following:

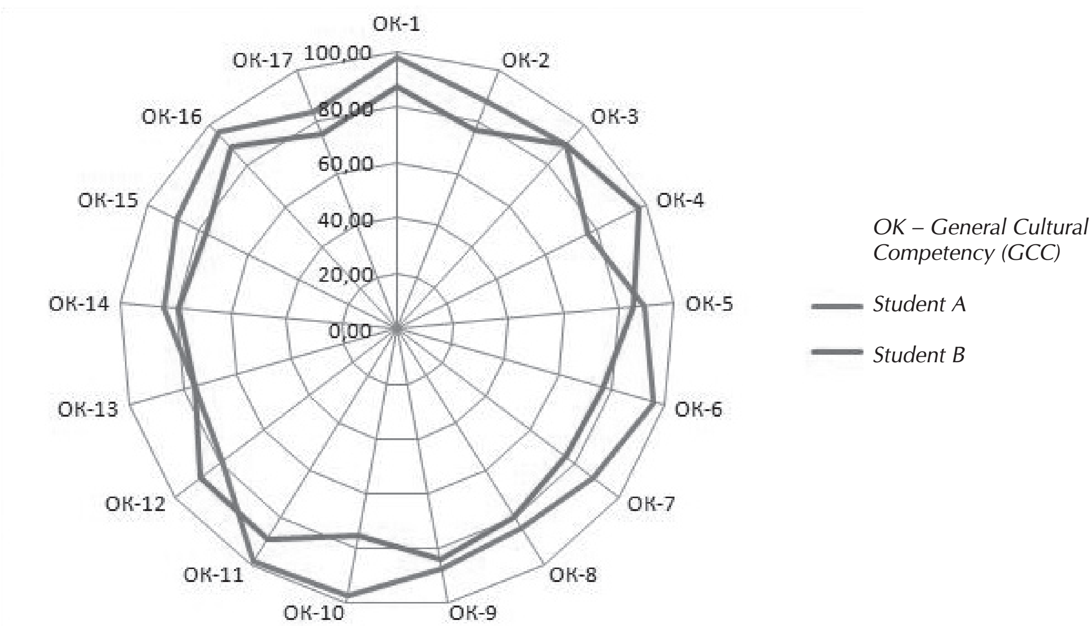
- Comparability of competency level evaluation results obtained in terms of interim attestation and diagnostic test data. Such comparison makes it possible to estimate the weight of a given discipline in the development of a competency;
- Comparability of academic performance results of different students (Fig. 3);
- Comparability interim and final attestation results;
- Possibility of integral assessment of educational program quality based on the evaluation results of graduates' training quality (entropy index(Fig.2)).

All this clearly demonstrates the essential convergent validity of the proposed approach.

At the same time, the possibility to compare entropy index of various student groups, different educational programs proves also external validity of the approach.

Complete evaluation of individual learning outcomes and educational program efficiency including, on one hand, assessment of academic performance results, and, on the other hand, monitoring of employer's satisfaction allows us to insure constant improvement of educational programs, provide the competitiveness not only of the graduates in labor market but also of a university in educational industry.

Fig.3. Comparison of Individual Learning Outcomes Based on the Development of General Cultural Competencies (2 students)



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MANAGEMENT SYSTEM OF INNOVATIVE DEVELOPMENT STRATEGY IN ENGINEERING

Moscow State Institute of Radio-engineering, Electronics and Automation (Technical University), MSIREA
A.V. Sidorin

The choice of innovation development strategy by an engineering university is the most adequate answer to the challenges conditioned by the governmental policy in the sphere of education, one of priorities of which is to provide innovation character for basic education, development and implementation of integrated innovation programs solving personnel and research problems in development of innovation economics on the basis of integration of education, scientific and production activities. Success in innovation development strategy realization of engineering university independently of its type is to the full extent determined by the management system efficiency of innovation strategy, the model of which is presented in the article.

A.V. Sidorin

Key words: *innovative development strategy management system in technical university, balanced scorecards, monitoring, risk management, mission, organization structure, competitive strategy, development perspectives, targets and aims of innovative developmentstrategy.*

Achievement of strategic goal of governmental policy in the sphere of education – to increase the availability of qualitative education meeting the requirements of innovative economic development, modern demands of society and every citizen - is solved by a set of tasks including implementation of the innovative character of basic education. Development of personnel efficiency for enterprises of high-technology industries is a general goal of engineering university activity in the sphere of innovation strategy of its development (ISD). Innovation strategy of engineering university is a goal-oriented activity in choosing priorities of perspective development and their achievement as a result of which a new quality of educational and research activity and management is to be provided [1,2]. Hence, ISD should and is implemented through progressive non-standard management decisions depended on the conditions of internal and external media, developed and taken in terms of specific peculiarities of engineering university activity [3]. Efficiency in implementation of innovation development strategy is determined by management system including the system of efficiency strategy indicator, monitoring of process performance, performance evaluation, development and realization of corrective actions and management decisions.

1. Management system structure of engineering university innovation development strategy.

The developed management system of innovation development strategy is based on methods of balanced score

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card (BSC), risk management, failure mode and effect analysis (FMEA), methods of qualimetry and scaling as well as management techniques such as QFD (Quality Function Deployment), FTA (Failure Tree Analysis), ETA (Events Tree Analysis).

The key concepts of ISD management system consist in the following:

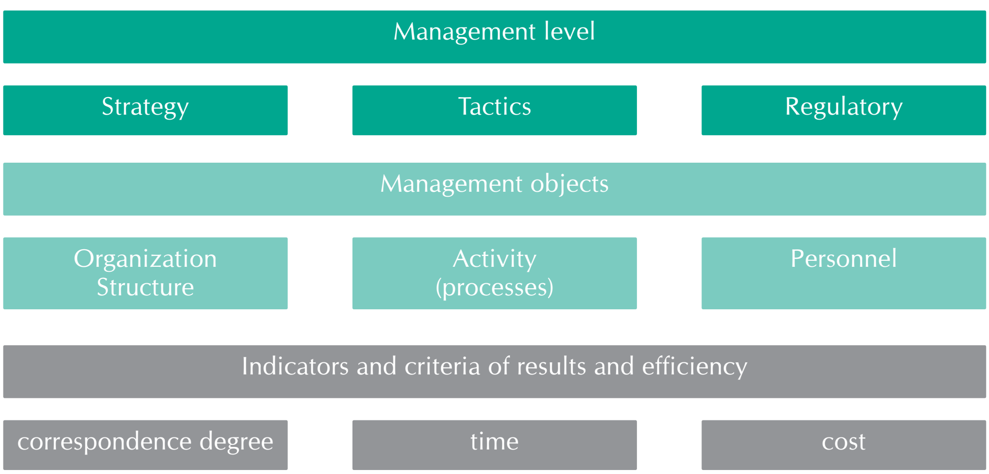
- ISD management is performed at three levels – strategic, tactic and regulatory-procedure;
- The objects of ISD management are at each level: structure, activity (processes) and personnel (staff) of university, students, graduates and employers;
- Results and efficiency of ISD are estimated by three indicators: quality, time and cost of goal achievement (Fig.1).

Criteria for ISD result and efficiency evaluation at all levels are correspondence of the results obtained to the values of planned indicators. At the strategy level management is performed on the basis of estimation of result correspondence by such elements of ISD as: mission, organization chart, competition strategy, development perspectives, goals and tasks (Fig. 2).

The basis of the Program tactic management is process result and efficiency evaluation including: evaluation of process structure and planning, evaluation of process goal and result indicator adequacy, process scheme, procedures of their performance as well as monitoring, development and performance of corrective and preventive actions, management decisions (Fig. 3).

Regulatory level of management system of engineering university innovation strategy development is goals and processes in documents necessary for their achievement structured in three groups - main, supporting and management processes (group of main processes includes those of educational, research and innovation activities), indicators and criteria of process results and efficiency, estimation methods of obtained result correspondence to the set goals. A structure of regulatory documents (RD) of management system of engineering university development innovation strategy is shown in Fig. 4. Documents of regulatory level for management system of engineering university development innovation strategy include analysis and evaluation procedures of educational, research and innovation activities, methods of indicator determination of the ISD process results, analytical methods of support for providing the process results.

Fig.1 Structure of Innovation Strategy System of Engineering University Development



2. Balanced score card in ISD management of engineering university

Planning, performance and evaluation of ISD results and efficiency is made on the basis of balanced score card (BSC). Balanced score card consists of groups of financial and non-financial indicators. Intention and task of BSC is to transform goals and tasks of university innovation strategy into specific indicators and coefficients. These indicators set the balance between the external account data and internal characteristics of the most significant business-processes, innovations, training and development in university. BSC allows for evaluation of the obtained results and forecast of development in all types of university activities. Balanced score card presents a set of objective, quantitatively estimable results and pre-set values and indicators in development. BSC accounts for the processes of strategic development in the educational and research sphere, cooperation with strategic partners and ISD financial processes, budgeting (Fig. 5). Structure of ISD efficiency indicators at each level (management and performance – Fig. 6) is presented in Fig. 7.

Every group of indicators is structured in four directions:

- indicators of performance evaluation for the ISD requirements;
- indicators of ISD resource evaluation;
- indicators of ISD financial activity and commercial coefficients;
- indicators of ISD personnel evaluation.

The basis for ISD efficiency analysis is qualimetric evaluation in terms of complex efficiency indicators defined as an average evaluation of five constituents (Table 1).

The weight indicators (βn) are stated by the method of expert estimation depending on the level of indicator importance Nn .

The complex ISD efficiency indicator is calculated by the formulae:

$$N = \frac{\sum_{i=1}^{4} \beta_n \cdot Nn}{\sum_{i=1}^{4} n}$$

3. Methods of risk management of balanced score card (BSC) in ISD implementation

Forecast of consequences in the conditions of uncertainty and probability

Fig.2 Objects of Engineering University Innovation Strategy Management and Evaluation

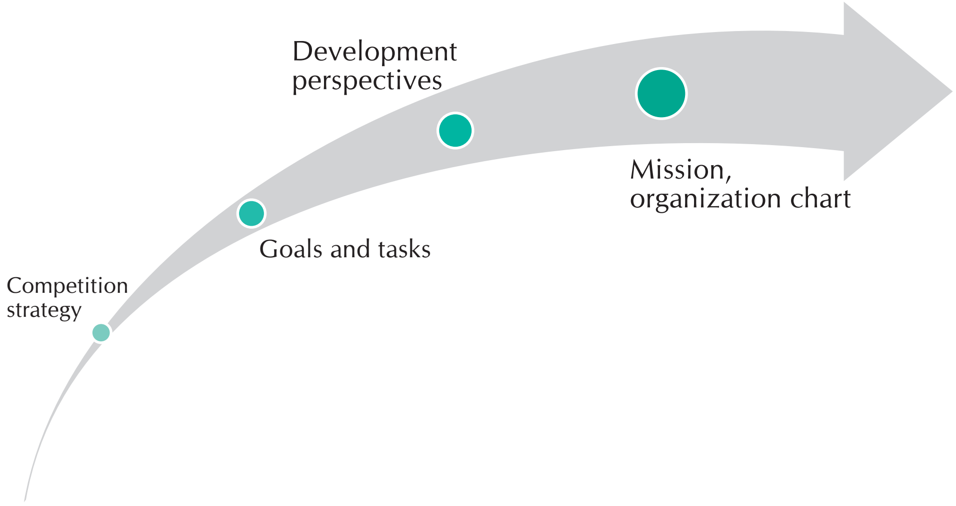


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Fig.3 Stages of Tactic Level in Management System of Engineering University Innovation Development Strategy

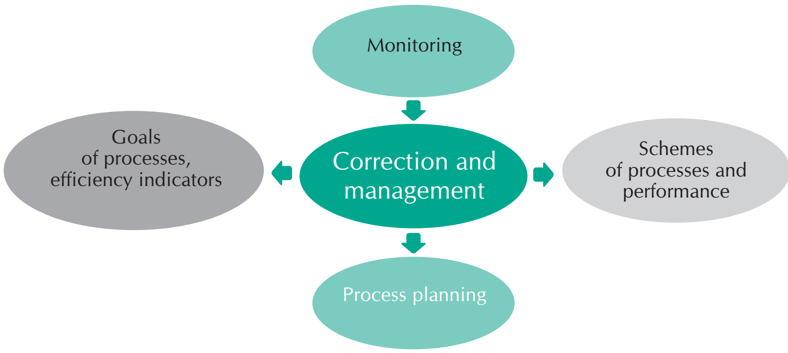
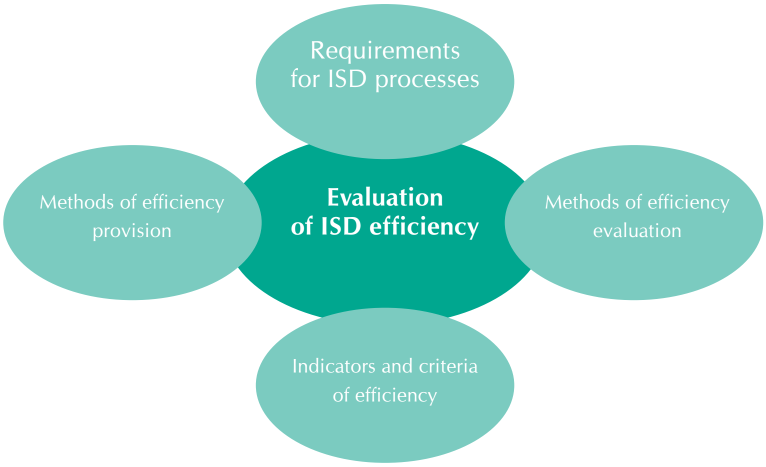


Fig.4 Structure of Regulatory Level in Management System of Engineering University Innovation Development Strategy



of consequences of possible deviations in ISD implementation as well as development and performance of appropriate preventive measures have become possible due to technique of risk management performed as a set of coordinated actions in ISD management. Risk assessment and forecasts of their consequences is carried out according to the recommendations of GOST p 52806-2007 Project risk management. General instructions.

To choose critical level of analyzed risks the initial conditions of probable event or circumstance, sequence of potentially hazardous events, any mitigating factors and characteristics as well as origin and frequency of possible negative consequences of identified hazards are studied in the course of risk value assessment. These criteria and measures are related to all activities of ISD and include the values of assessment uncertainties. The objective of risk assessment is taking decisions based on risk analysis establishing the priorities in taking decisions in terms of risk to which one needs to respond first of all.

Risk analysis in ISD realization of engineering university is to be performed taking into account the peculiarities of its research-educational and innovative activity using such methods as «event tree analysis» (ETA), «failure modes and effects analysis» (FMEA), «failure tree analysis» (FTA), «hazard and operability study» (HAZOP), «human resource analysis» (HRA), «preliminary hazard analysis»

Fig.5 Constituents of Balance Score Card in Management System of Engineering University Innovation Development Strategy

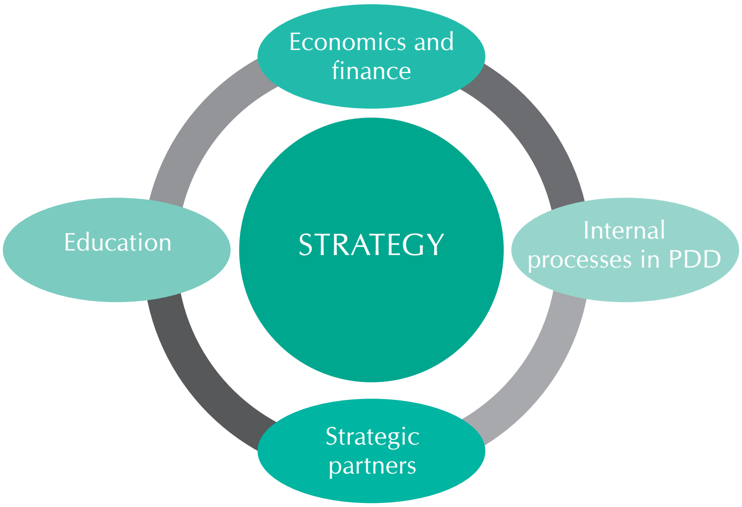


Fig.6 Groups of ISD Efficiency Indicators

Fig.7 Structure of Balanced Score Card (BSC)

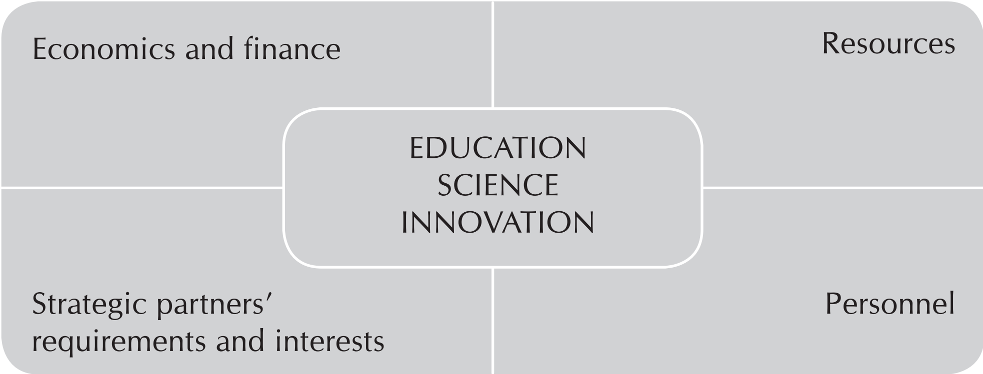


Table 1. Constituents of ISD efficiency evaluation

№ п.п	Indicator designation N_n	Intention of indicator	Weight indicator (β_n) ($0 < \beta_n < 1$)
1	N_1	Requirement performance evaluation	β_1
2	N_2	Financial and commercial activity evaluation	β_2
3	N_3	Education, research and innovation activity evaluation	β_3
4	N_4	Personnel evaluation	β_4
5	N_5	Resource evaluation	β_5

(PHA), «reliability structure diagram of ISD».

The external risks conditioned, as a rule, external objective conditions and the internal risks caused by conditions of ISD performance are analyzed. Types of analyzed risks in the ISD system management are shown in Table 2.

4. Monitoring of ISD performance

In ISD monitoring the initial information is obtained through questionnaire, inner audits, self-control, testing.

Character, periodicity of collection and volume of data is set in terms of the condition of information storage on continuous process at its modeling in the form of sequence of discrete values of information units (Fig. 8).

For analysis and evaluation of such qualimetric methods as expert evaluation method, calculation methods (differential – for evaluation of individual elements of the process and complex one – for evaluation of the process as a whole) are used. Analysis and evaluation are performed by the methods based on index system and efficiency criteria.

To evaluate individual processes and their elements by differential and complex calculation methods simple and complex quality indexes are used. Processes to which calculation methods cannot be applied are evaluated by the expert evaluation method.

The principle stages of monitoring: establishment of threshold index values, determination of true values within the analyzed period, comparison of true and threshold values and evaluation of efficiency using the set grade scale (Fig. 9).

Evaluation results are used in analysis of ISD performance results in all activity directions, determination of efficiency level in developed grade scale, evaluation of process consistency, development of management decisions, formation of database on the course and results of ISD performance.

Periodicity of data collection in the system is defined by the process variability. Quick changing system processes include those of educational, research and innovation activities, development of scientific-engineering production and their commercialization. It implies the necessity of constant data on them. The data about set and stable processes which can include management and supporting processes (including resource management, infrastructure management, operating environment management, personnel management) can be collected and analyzed with higher periodicity.

Monitoring efficiency in the ISD management system of engineering university can be increased by using continuous acquisition and life-cycle support technologies (CALS). At this monitoring organization, data collection can be performed in common information space at all stages. In the integrated information environment information acquisition and processing on ISD processes as well as introduction of changes into the processes and other management decisions are performed by means of formalized functional models in real time scale.

Table 2. Composition and structure of risks analyzed in management engineering university innovation development strategy

Risks	Basic causes
EXTERNAL	
Country	Peculiarities of state law, changes in forms of property etc.
Currency	Changes in currency exchange, currency regulation
Tax	Changes in tax policy, tax rates
Force majeure	Natural and technogenic accidents
INTERNAL	
Organization	Low level of ISD performance organization, planning errors, forecast errors, inefficient management, poor organization of executive work etc.
Resource	Insufficient level of resource availability, fails to deliver, low qualification of executive workers, absence of resource reserves
Investment	Investment risks: equipment and row material delivery interruptions, errors in investment project development or innovation activity
Financial	Risks associated with probabilities of financial losses (investment risks, direct financial losses) and risks connected with circumstances, in particular, financial losses due to the fault of ISD financial bodies, employees or partners due to changes in conditions of ISD performance
Portfolio	Changes in contract terms, errors in choice of activity directions, incorrect choice of financial operations
Credit	Credit and interest default, non-compliance with credit conditions, borrower's involuntary bankruptcy, changes in borrower's paying capacity, incorrect choice in innovations, incorrect calculations, application and introduction of research developments
Legal	Licenses used, patent rights, breach of contracts, trials with external partners, internal trails,
Social	Risks directly connected with employees' working capacity as well as their personal qualities and labor conditions
Commercial	Risks associated with business activity, in particular, aimed at profit maximization and in the course of innovation activity, purchases and equipment delivery
Production	Risks associated with unforeseen deviation from preset process performance in terms of the Program due to different reasons as well as those conditioned by incorrect usage of equipment and techniques, basic and working asserts, production resources and working time
Professional	Risks associated with performance of ISD professional duties by executive officers

Fig.9 Algorithm of Result and Efficiency Evaluation of ISD Processes as a whole

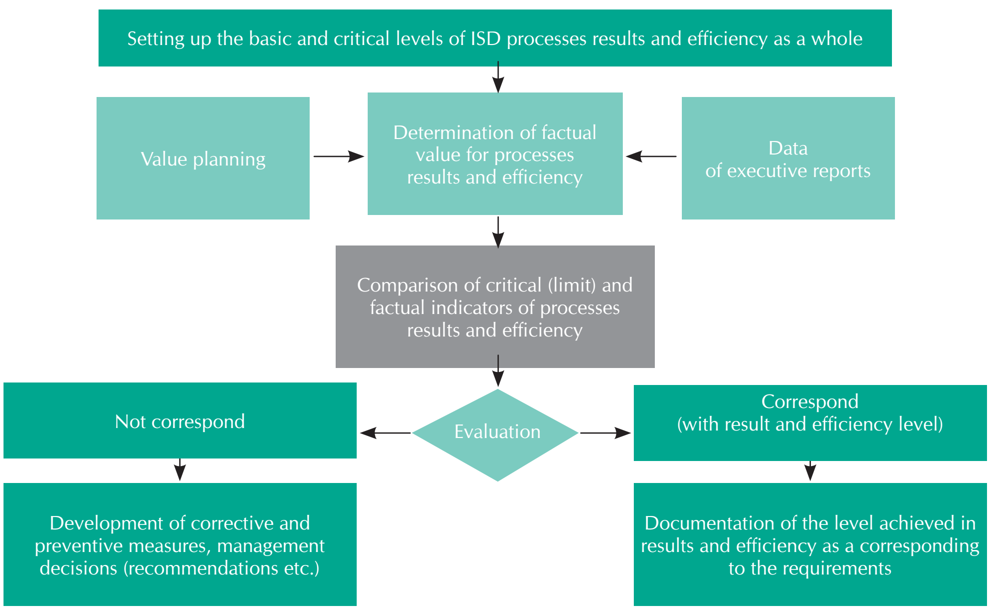
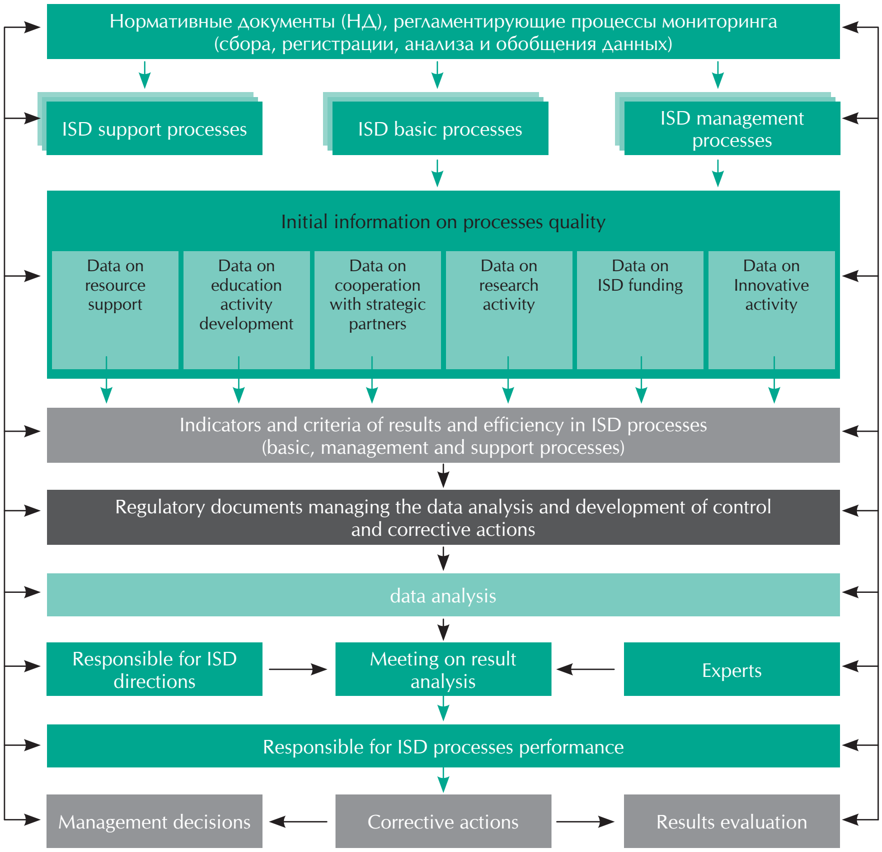


Fig.8 Monitoring of ISD Performance



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TECHNOLOGY TRANSFER. COMPARATIVE ANALYSIS OF RUSSIAN, AMERICAN AND BRITISH UNIVERSITIES.

National Research Tomsk Polytechnic University
E.O. Akchelov, S.L. Eremina

The article analyzes the technology transfer within Russian, American and British Universities showing the statistic significance in order to accept or reject hypothesis about opportunity to use USA and UK experience in Russian universities.

Key words: *technology transfer, knowledge-based economy, Mann-Whitney criterion.*

E.O. Akchelov

S.L. Eremina

Introduction

The comparative analysis of technology transfer (transfer of technology) in Russia, USA and Great Britain is the research topic conducted by the Russian Engineering Education Association (REEA). "Knowledge- based economy" is that economy that is directly based on technology and further advancement and application of relevant knowledge and information [1, p. 7]. The major role in establishing this economy is innovation activities defined as R&D and further implementation of other researches. Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations [2, p. 31]. The research community (i.e. research laboratories and higher education institutions) being generators and distributors of knowledge and performing the function of technology transfer plays a significant role in innovation activities. In the fast-moving environment the research community predominates in the generation of knowledge for technological progress and development of overall cultural principles for information exchange (swapping). However, in the case of the knowledge-based economy, the research community should be an equilibrium fulfilling the following roles of an "architect" of knowledge (research), a "distributor" of knowledge (learning) and a "transfer" of this knowledge to ensure that other social and economic institutions, including small and average businesses, are accessible to this information (knowledge transfer). By developing the interconnection between the research community and private enterprises Organization for Economic Co-operation and Development (OECD) accelerates the knowledge transfer [1, p. 7].

The development of knowledge-based economy is a challenge in Russia. The fuel-energy sector provides about 1/3 of the gross domestic product (GDP) and approximate 40% of all custom duties and taxes in the budget [3]. The energy fraction in the country's GDP is 30%, while Fuel & Energy Companies provide 52% of the federal income budget [4]. It is obvious that economy significantly depends on the export of resources.

Let's consider the key concepts used in the following article. Technology transfer – is the process of moving new information, products or processes from one organization to another for potential commercial interest [5, p.145]. "Technology – practical application of knowledge in one specific area [6]. When knowledge performs a specific function, solves one problem then it transfers into technology. In the following research the "architect" of technology – university, while its "consumer" – enterprises of small and average businesses.

University technology transfer is vertical, i.e. technology is a step-by-step process from fundamental research to production based on this technology. Technology transfer in Russia, USA and Great Britain is quite different due to the culture diversity in universities and business, as well as, the motivation and control mode of the technology transfer management. According to American literature the technology transfer problem from university to business involves the study of indexes, for example, the ratio of patent cost to royalty [5, p.146]. The benchmark in technology transfer in USA is the adoption of the Bayh-Dole Act of 1980. Bayh-Dole permits a university to pursue ownership of an invention in preference to the government [5, p.146]. The positive result of this act was the increase of patents, i.e. less than 250 patents before 1980 to 2000 patents after 1980 [5, p.146]. This Act also influenced and furthered the cooperation between universities and enterprise representatives, where universities play an important role in the development of new technologies within modern area of knowledge [5, p.146]. According to Moveri the major effect of the Bayh-Dole Act was the fact that the universities could actively promote and commercialize the invention within the framework of the university itself. [5, p.146]. For example, for biomedical companies this is the close interconnection between new products and the university research, while for other enterprises the funding of fundamental and applied research is more effective than direct financing of a new product [5, p.146].

Due to the commercialization of university technology approximately 250 thousand workplaces were created annually [5, p.146]. Approximate 10% of new products were implemented into production as a result of the latest university research developments [5, p.146].

Traditionally, in Great Britain more attention is focused on publications than on patenting, although the British research system is the most effective one in the world today [5, p.146]. Another similar system is the so-called RAE (Research Assessment Exercise).[1] Salter [5, p.146] underlined the fact that such a focus on publications can be explained by the "conventional viewpoint" based on the idea that the research target is only information. This is the difference between British and USA, the latter of which states that the basic research target is invention patent.

During the last few years the government of GB has enforced the development of technology transfer from universities to businesses (for example, two project programs were launched on initiative of "University Challenge": one- funding projects in the seed stage and the second- program HEROBC[1] to improve the technology transfer infrastructure in universities).

Lambert [5, p.147] identified the existing connection between universities and enterprise representatives, as well as, the future potential of these co-operations. The author considers that one of the major challenges is the lack of modern technology in universities and the general drawback of HEROBC for enterprises within GB. Hi-tech business based on Oxford and Cambridge researches increases the employment of the population within the Universities' territories and demonstrates the "potential economic regeneration" for different regions of GB.

Planned economy in the former Soviet Union, including planned science development, promoted the development of modern military technique models, leading positions in space exploration, and some other areas. However, all in all, this did not further the improvement of the population living standards as abroad. Although the former Soviet Union was the first in fundamental sciences, it was unable to create an effective mechanism that could have implemented different innovations into the civil sphere, which, in its turn, leads to the upturn of the country itself. There did not exist those economic incentives to commercialize the inventions of not only scientific groups, but also single scientists. The result is economic lag from highly-developed countries.

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[1] *Higher Education Reach Out to Business and Community*

V.V. Putkov [7] understands that the problem of technology transfer in RF is the insufficient development of the legislative basis in promoting innovation activities; development of stock market deficiency; intellectual property (IP) market; tools to support the innovation activities; and weak innovation infrastructure. In most cases, Russian business is not interested in implementing new Russian technology and funding research. A serious barrier in furthering innovation products into the Russian market, or even foreign market, is the "sluggish' development of the juridical field and no defense of infringement.

L.A. Bokov, A.V. Kobzev and others underlined that the problem of technology transfer involves the disbalance of domestic science funding; research sensitivity and overall inefficiency of higher education institutions to implement serious technological projects; technology orientation towards military clients, but not market consumers [8].

Research target

M. Dexter in his investigations [5, p. 145-155], identifying the comparative technology transfer problem in universities of Russia, USA and GB, presupposed the definition of statistically important differences in the respondents' answers of these countries. Based on M. Dexter methodology questionnaire was developed and adjusted to Russian conditions.

Problem investigation of technology transfer in Russian[2]

Basic types of university activities

	1	2	3	4	5
New technology patenting					
Applied research					
Publication of research results					
Teaching, promotion of knowledge					
Fundamental research					
Technology transfer into business					
Upgrading intelligence level					

Dimension of organized structure coordination of the universities in technology transfer

Quite coordinated	Coordinated	Moderately coordinated	Uncoordinated	Extremely uncoordinated

Major motives for universities in technology transfer implementation

	1	2	3	4	5
Development of small innovative enterprises in accordance to FL(Federal Law)- 217					
Income diversification					
Income increase for university staff					
Business support					
Improvement of university prestige					
University staff result satisfaction of one's activities					
Shaping human resources					

Key business motives in university technology implementation

	1	2	3	4	5
Access to new ideas and technologies					
Risk decrease of technology transfer to competitors					
Expenses decrease in R & D					
Accelerated expansion into new markets					
Regular diverse cooperation with universities					

[2] *http://aeer.ru/php/anketa_transf.php*

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Shaping human resources					

Technology transfer barriers in business

	1	2	3	4	5
Inadequate evaluation of the financial result					
Interaction structure problems between universities and businesses					
No effective infrastructure for technology transfer					
Cultural differences between universities and businesses					
Insufficient number of funding sources for universities					
Lack of entrepreneurs in universities					

Accessibility of university technologies

Very accessible	Accessible	Rather inaccessible	Partially inaccessible	Practically inaccessible

Key problems of university technology accessibility for business

	1	2	3	4	5
Difficult process coordination of technology transfer					
Non-confidence of businesses to universities					
No attempts to implement technologies into business					
Prolongation of negotiations in technology transfer					
Lack of sophisticated technologies					
Insufficient funding of technology transfer					

Activity rate of technology transfer into business

High	Average	Low

Positive outcomes of technology transfer for universities

	1	2	3	4	5
Mobilization of financial resources					
Income increase of staff					
Governmental funding increase for on-demand technologies					
Realistic financial foresight for universities					
Measures in better insight of business concept execution					
Accessibility increase of financial resources					
Autonomous technology transfer structure enforcement					
Reduction of bureaucracy					
Interaction enhancement between universities and businesses					

Respondents suggest discussing and evaluating the significance of the following range of issues: basic types of university activities, major motives for universities in technology transfer implementation, technology transfer barriers in business and others. This evaluation should be conducted according to the 5-Likert (type) scale[3] for all questions except activity rate of technology transfer in business which is evaluated to the 3-scale. Respondents' answers were divided into the following pairs: Russia and USA, Russia and Great Britain..

Research methodology

[3] Scale showing the assumption probability of the existing fact of measurable variable as latent and indiscrete / http://www.proresearch.ru/publish/glos30.php

Data analysis is based on the bi-variable discrepancy test to define statistically the important differences in the respondents' answers of Russia, USA, and Great Britain in accordance to Mann-Whitney criterion [9].[4],

$$U = n_1 n_2 + \frac{n_x(n_x+1)}{2} - T_x \qquad (1)$$

where, n_1 – first sample coverage; n_2 – second sample coverage; n_x – coverage more of n_1, n_2 coverage; T_x – more of two rank sum.

Research results

The participants of the research were the following- rectors, vice-rectors of R & D and directors of technology transfer centers of Moscow State Automobile & Road Technical University (MSARTU), Moscow State Technical University n.a. N.E. Bauman, Tulsk State University, Ulyanovsk State University and other universities and members of the Russian Engineering Education Association (Table 1-9). The sample coverage for USA- 57, GB- 32 and Russia – 16. The value p1 is the statistic certainty of the zero hypothesis which shows that there is no difference between the respondent answers of USA and Russia, while p2 shows statistic certainty of the zero hypothesis. The columns Russia – USA average rank and Russia- Great Britain average rank show the relative importance of the question for the countries. For those countries with a low rank the question is more important than for those countries with a high rank.

Basic types of university activities

The question answers are marked in percents, respectively, * 90% statistic difference value in respondents' answers ** - 95%, *** - 99%.

Analysis of Russian and American respondents' answers (Table 1) indicated the following:

- similarity in answers to question 1.1 (for Russian respondents more important than for American respondents) , answers to question 1.4 (for American respondents more important than for Russian respondents); answers to question 1.6
- differences in answers to questions 1.2, 1.5, 1.7 (statistic difference value 95%), answers to question 1.3 (statistic difference value 90%).

Analysis of Russian and British respondents' answers (Table 1) indicated the following:

- similarity in answers to questions 1.3, 1.4, 1.6, 1.7 (for British respondents more important than for Russian respondents);
- differences in answers to questions 1.1, 1.2 (statistic difference value 90%); question 1.5.

Sequential comparison of the question- answers of the pairs Russia- USA and Russia- Great Britain indicated that question- answers were the following: technology transfer and teaching, promotion of knowledge – the respondents' answers were identical; question- fundamental and applied research – their opinion differed significantly. This could be explained by the fact that technology transfer and teaching are the major functions of any university, while the second answer involves the different approaches in fundamental and applied research.

Table 1. Basic types of university activities

[4] Zero hypothesis presumes that there are no significant statistic differences between the respondent answers of the country-participants.

Question	Country	1	2	3	4	5	Russia-USA average rank	Russia-GB average rank
1.1. New technology patenting $p_1=0.5552$, $p_2=0.0658$*	Russia	31.21	18.75	43.75	0	6.25	34.2	19.2
	USA	12.5	32	30.5	21.5	3.5	37.8	-
	GB	3	34.5	31	22	9.5	-	27.1
1.2. Applied research $p_1=0.0033$**, $p_2=0.0643$*	Russia	56.25	31.25	6.25	0	6.25	23.2	19.2
	USA	17	31	38.5	9.5	4	40.9	-
	GB	26	45	19.5	6.5	3	-	27.2
1.3. Publication of research results $p_1=0.0735$*, $p_2=0.5485$	Russia	50	37.5	6.25	0	6.25	45.4	26.3
	USA	82	7	5.5	2	3.5	34.6	-
	GB	61.5	26	3	6.5	3	-	23.6
1.4. Teaching, promotion of knowledge $p_1=0.2891$, $p_2=0.5353$	Russia	68.75	0	25	0	6.25	42	26.3
	USA	87.5	1.8	1.9	1.8	7	35.6	-
	GB	80.5	6.5	0	0	13	-	23.6
1.5. Fundamental research $p_1=0.0164$**, $p_2=0.1074$	Russia	31.25	50	12.5	0	6.25	48.3	29.1
	USA	75	12.5	3.5	2	7	33.8	-
	GB	65.5	19	3	3	9.5	-	22.2
1.6. Technology transfer into business $p_1=0.7795$, $p_2=0.7949$	Russia	25	43.75	18.75	6.25	6.25	38.3	25.3
	USA	16	37.5	30.5	14	2.	36.6	-
	GB	15.5	40.5	25	9.5	9.5	-	24.1
1.7. Upgrading intelligence level $p_1=0.0466$**, $p_2=0.5029$	Russia	18.75	25	43.75	0	12.5	46.4	26.4
	USA	36	41	12.5	7	3.5	34.4	-
	GB	25	34.5	25	3	12.5	-	23.5

Dimension of organized structure coordination of the universities in technology transfer

Analysis of Russian and American respondents' answers (Table 2) showed the absence of similar answers. Analysis of Russian and British respondents' answers showed a difference with statistic difference value of 99%. This indicates that there exists a different approach in the organized structure coordination of technology transfer in Russia, USA and Great Britain.

Table 2. Dimension of organized structure coordination of the universities in technology transfer

Country $p_1=0.2041$, $p_2=0.0003$***	Structure					Russia-USA average rank	Russia-GB average rank
	Quite coor-dinated	Coordinated	Moderately coordinated	Uncoordinated	Extremely uncoordinated		
Russia	0	50	50	0	0	31	14
USA	2	30	61	7	0	38.7	-
GB	0	10	40	47	3	-	29.8

Major motives for universities in technology transfer implementation

Analysis of Russian and American respondents' answers (Table 3) indicated the following:

- similarity in answers to questions 3.1(for Russian respondents more important than for American respondents); answers to questions 3.2, 3.5, 3.7 (practically identical value); answers to question 3.6 (for American respondents more important than for Russian respondents); answers to question 3.7
- differences in answers to questions 3.3, 3.4 (statistic difference value 95%).

Analysis of Russian and British respondents'answers (Table 3) indicated:

- similarity in answers to questions 3.2 (for British respondents more important than for Russian respondents); answers to question 3.5 (practically identical value); answers to question 3.6 (for Russian respondents more important than for British respondents),
- differences in answers to questions 3.1, 3.4 (statistic difference value 99%); answers to questions 3.3, 3.4 (statistic difference value 95%).

Sequential comparison of the question- answers of the pairs Russia- USA and Russia-Great Britain indicated that the questions income diversification, improvement of university prestige, as well as, university staff result satisfaction of one's activities the respondents gave identical answers, while such questions as, development of small innovative enterprises, income increase for university staff and business support the respondents had different opinions. This can be explained by the fact that such factors as income diversification, improvement of university prestige, as well as, university staff result satisfaction of one's activities are acute in all of these countries. However, the development of small innovative enterprises is not so significant due to the world-wide experience of these countries (USA and GR) in this sphere. The different answers to the question income increase for university staff can be explained by the fact that the income of university staffs in the USA and GB is significantly higher than it is in Russia, so for Russian respondents this question is very important. The different answers to the question business support can be explained by the fact that the businesses in the USA and GB need the support of universities and not visa versa (the success of a large number of companies, including the most popular and expensive world brands, is based only and only on the support of different universities; for example, Google Co. was developed within the walls of the Stratford University[5]).

Table 3. Major motives for universities in technology transfer implementation

Question	Country	1	2	3	4	5	Russia-USA average rank	Russia-GB average rank
3.1. Development of small innovative enterprises in accordance to FL(Federal Law)- 217 $p_1=0.2187$, $p_2=0.0028$***	Russia USA GB	18.75 11 0	37.5 32 17	25 24 26.5	12.5 20 30	6.25 13 26.5	31.2 38.6 -	15.9 - 28.8
3.2. Income diversification $p_1=0.992$, $p_2=0.4715$	Russia USA GB	18.75 16 37	31.25 34 20	37.5 37.5 23	6.25 11 13	6.25 1.5 7	36.9 37 -	26.6 - 23.5
3.3. Income increase for university staff $p_1=0.0324$**, $p_2=0.0278$**	Russia USA GB	31.25 14.5 7	43.75 28.5 40	18.75 41 30	0 14.5 13	6.25 1.5 10	26.9 39.8 -	18.2 - 27.7

[5] http://www.google.ru/intl/ru/about/corporate/company/history.html

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3.4. Business support $p_1=0.0188^{**}$, $p_2=0.003^{***}$	Russia USA GB	0 7 27.5	18.75 46.5 38	50 30.5 20.5	18.75 11 10.5	12.5 5 3.5	48 33.9 -	33 - 20.2
3.5. Improvement of university prestige $p_1=0.6745$, $p_2=0.992$	Russia USA GB	43.75 37 40	25 24 33.5	18.75 26 3.5	0 7.5 16.5	12.5 5.5 6.5	35 37.6 -	24.4 - 24.5
3.6. University staff result satisfaction of one's activities $p_1=0.234$, $p_2=0.5892$	Russia USA GB	31.25 52 30	43.75 27 27	12.5 14 27	6.25 3.5 6	6.25 3.5 10	42.6 35.4 -	22.9 - 25.3
3.7. Shaping human resources $p_1=0.8259$, $p_2=0.034^{**}$	Russia USA GB	25 34 13	56.25 30 33.5	12.5 21.5 17	0 12.5 23.5	6.25 2 13	35.9 37.3 -	18.4 - 27.5

Analysis of Russian and American respondents' answers (Table 4) indicated

Analysis of Russian and American respondents' answers (Table 4) indicated:

- similarity in answers to questions 4.2, 4.4 (for Russian respondents more important than for American respondents); answers to question 4.1 (for American respondents more important than for Russian respondents),
- differences in answers to question 4.5 (statistic difference value 95%), answers to question 4.3 and 4.6(statistic difference value 99%).

Analysis of Russian and British respondents'answers (Table 4) indicated:

- weak similarity in answers to questions 4.1, 4.2, 4.4 (for British respondents more important than for Russian respondents),
- strong similarity answers to question 4.5 (practically identical value),
- differences in answers to questions 4.3 and 4.6(statistic difference value 99%);

Sequential comparison of the question- answers of the pairs Russia- USA and Russia- Great Britain indicated that the questions expenses decrease in R & D, shaping human resources showed that the respondents' answers were different, while such answers to the question as regular diverse cooperation with universities were identical as those to of Russia- Great Britain.

The different answers to the question expenses decrease in R & D can be explained by the fact that there exist different approaches to research – business. The specific fraction of enterprises to R&D departments is very high in the USA and Great Britain, while in Russia this index is far from being perfect. As the respondents' answers to the question shaping human resources are quite different, it can be explained that the problem of personnel shortage in technology transfer is especially acute in Russia, while for the USA and Great Britain it has no significance.

Table 4. Key business motives in university technology implementation

Question	Country	1	2	3	4	5	Russia-USA average rank	Russia-GB average rank
4.1. Access to new ideas and technologies $p_1=0.1835$, $p_2=0.3077$	Russia	50	31.25	12.5	0	6.25	43.3	27.4
	USA	72	19.5	0	1.5	7	35.2	-
	GB	71.5	9.5	9.5	0	9.5	-	23
4.2. Risk decrease of technology transfer to competitors $p_1=0.5552$, $p_2=0.1031$	Russia	6.25	25	37.5	25	6.25	34.2	29.2
	USA	5.5	18	42	22	12.5	37.8	-
	GB	19	31	37.5	12.5	0	-	22.2
4.3. Expenses decrease in R&D $p_1=0.0042$***, $p_2=0.0076$***	Russia	6.25	18.75	56.25	18.75	-	50.4	32.2
	USA	28	44	19.5	3.5	5	33.2	-
	GB	22	50	22	3	3	-	20.7
4.4. Accelerated expansion into new markets $p_1=0.8103$, $p_2=0.1362$	Russia	6.25	31.25	43.75	18.75	0	38.2	28.8
	USA	18	25.5	31	18	7.5	36.7	-
	GB	25	34.5	28	9.5	3	-	22.4
4.5. Regular diverse cooperation with universities $p_1=0.0114$**, $p_2=0.9203$	Russia	6.25	31.25	37.5	18.75	6.25	48.9	24.8
	USA	35	35	19.5	5.25	5.25	33.7	-
	GB	0	37.5	44	15.5	3	-	24.3
4.6. Shaping of human resources $p_1=0.0002$***, $p_2=0.0001$***	Russia	50	37.5	6.25	0	6.25	19.6	12.5
	USA	11	23.5	25.5	22	18	41.9	-
	GB	0	22	44	18.5	15.5	-	30.5

Technology transfer barriers in business

Analysis of Russian and American respondents' answers (Table 5) indicated:

- similarity in answers to questions 5.1, 5.2 (for Russian respondents more important than for American respondents); answers to question 5.5 (practically identical value),
- differences in answers to question 5.3, 5.6 (statistic difference value 90%), answers to question 5.4 (statistic difference value 99%).

Analysis of Russian and British respondents' answers (Table 5) indicated:

- strong similarity in answers to questions 5.1, 5.2, 5.5 (practically identical value); answers to question 5.3 (for Russian respondents more important than for British respondents) ,
- differences in answers to questions 5.6 (statistic difference value 90%), answers to question 5.4 (statistic difference value 90%).

Sequential comparison of the question- answers of the pairs Russia- USA and Russia- Great Britain indicated that the answers to the questions inadequate evaluation of the financial result, interaction structure problems between universities and businesses, as well as, insufficient number of funding sources for universities are of high priority for each of the country-participant. At the same time the respondents' answers of these countries were quite different to the following questions- cultural differences between universities and businesses and lack of entrepreneurs in universities. This can be explained by the fact that the cultural differences between universities and businesses in the USA and GB practically don't impede their effective interaction, in comparison to the Russian conditions where the situation is visa versa.

Table 5. Technology transfer barriers in business

Question	Country	1	2	3	4	5	Russia-USA average rank	Russia-GB average rank
5.1. Inadequate evaluation of the financial result $p_1=0.3271$, $p_2=0.865$	Russia USA GB	25 7 12.5	25 29 37.5	31.25 42 34.5	6.25 15 12.5	12.5 7 3	32.4 38.3 -	24 - 24.8
5.2. Interaction structure problems between universities and businesses $p_1=0.3222$, $p_2=0.9045$	Russia USA GB	18.75 11 25	37.5 33 31	31.25 34.5 28	6.25 14.5 9.5	6.25 7 6.5	32.3 38.3 -	24.9 - 24.3
5.3. No effective infrastructure for technology transfer $p_1=0.0949^*$, $p_2=0.3173$	Russia USA GB	31.25 7 6.5	25 31 47	31.25 42 31	12.5 11 9	0 9 6.5	29.1 39.2 -	21.6 - 25.9
5.4. Cultural differences between universities and businesses $p_1=0.0001^{***}$, $p_2=0.0023^{***}$	Russia USA GB	0 33 28	18.75 31.5 34.5	37.5 30 25	37.5 3.5 9.5	6.25 2 3	55 32 -	33.3 - 20.1
5.5. Insufficient number of funding sources for universities $p_1=0.8493$, $p_2=0.9045$	Russia USA GB	56.25 47.5 53	12.5 30 28	18.75 12 9.5	12.5 7 6.5	0 3.5 3	36.1 37.3 -	24.9 - 24.3
5.6. Lack of entrepreneurs in universities $p_1=0.0512^*$, $p_2=0.0719^*$	Russia USA GB	37.5 14 15.5	25 28 22	31.25 31.5 40.5	0 23 19	6.25 3.5 3	27.8 39.6 -	19.3 - 27.1

Accessibility of university technologies

The data analysis in Table 6 showed that there is an insignificant similarity in the question- answers of the Russian- American respondents and a moderate similarity in those of the Russian-British respondents. The conclusion is that equipment in American universities is more accessible than in Russian universities.

Table 6. Accessibility of university technologies

Country p_1=0.1802, p_2= 0.4777	Very accessible	Accessible	Rather inaccessible	Partially inaccessible	Practically inaccessible	Russia-USA average rank	Russia-GB average rank
Russia	0	37.5	50	12.5	0	43.3	22.4
USA	10.5	44	38.5	7	0	35.2	-
GB	3	17	67	10	3	-	25.5

Key problems of university technology accessibility for business

Analysis of Russian and American respondents' answers (Table 7) indicated:

- similarity in answers to questions 7.1, 7.2, 7.3 (for Russian respondents more important than for American respondents); answers to question 7.5 (practically identical value),
- differences in answers to question 7.4 (statistic difference value 90%), answers to question 7.6 (statistic difference value 99%).

Sequential comparison of the question- answers of the pairs Russia- USA and Russia- Great Britain showed that the respondents consider that the key problems in university technology accessibility for businesses (except in the case of negotiations and funding) is the same in these countries, i.e. prolongation of negotiations and non-confidence of businesses to universities. It should be noted that such factors as non-confidence of businesses to universities, no attempts to implement technologies into business, as well as, the lack of sophisticated technologies is common not only for Russia, but also for the USA and Great Britain.

Table 7. Key problems of university technology accessibility for business

Question	Country	1	2	3	4	5	Russia-USA average rank	Russia-GB average rank
7.1. Difficult process coordination of technology transfer p_1=0.3077, p_2=0.4902	Russia	6.25	25	43.75	25	0	32.2	22.5
	USA	0	21	45	24.5	9.5	38.4	-
	GB	3	12.5	59.5	22	3	-	25.5
7.2. Non-confidence of businesses to universities p_1=0.3524, p_2=0.4777	Russia	25	18.75	31.25	25	0	32.6	26.6
	USA	13	17	43.5	17	9.5	38.2	-
	GB	19	44	25	9	3	-	23.5
7.3. No attempts to implement technologies into business p_1=0.6818, p_2=0.4295	Russia	50	25	18.75	6.25	0	35.1	22.2
	USA	42.5	34.5	9.5	7.5	6	37.5	-
	GB	34.5	40.5	9.5	12.5	3	-	25.6
7.4. Prolongation of negotiations in technology transfer p_1=0.0836*, p_2=0.2713	Russia	6.25	18.75	43.75	25	6.25	45.1	27.7
	USA	17	26	43.5	9.5	4	34.7	-
	GB	6.5	29	55	6.5	3	-	22.9
7.5. Lack of sophisticated technologies p_1=0.8729, p_2=0.5687	Russia	31.25	31.25	18.75	12.5	6.25	37.8	26.2
	USA	20	45.5	23.5	5.5	5.5	36.8	-
	GB	35.5	32.5	19.5	6.25	6.25	-	23.7
7.6. Insufficient funding of technology transfer p_1=0.0034***, p_2=0.1164	Russia	56.25	12.5	12.5	12.5	6.25	23.2	20
	USA	4	28	39.5	19	9.5	40.9	-
	GB	19.5	35.5	26	16	3	-	26.8

Activity rate of technology transfer into business

The data analysis in Table 8 showed that there is no similarity in the question- answers of the three respondents and in this case the statistic difference value is 95% (in comparing the question answers of the Russian – American respondents the statistic difference value is 99%). It is recommended not to apply the experience of the foreign respondents. It can be stated that the activity rate of technology transfer from universities into businesses in America and Britain are rather high in comparison to Russia.

Table 8. Activity rate of technology transfer into business

Country $p_1=0.0016$***, $p_2=0.0155$**	High	Average	Low	Russia-USA average rank	Russia-GB average rank
Russia	6.25	50	43.75	51.8	31.4
USA	31.5	65	3.5	32.8	-
GB	17	80	3	-	21

Positive outcomes of technology transfer for universities

Analysis of Russian and American respondents' answers (Table 9) indicated:

- similarity in answers to questions 9.3 (for Russian respondents more important than for American respondents); answers to question 9.5, 9.7 (for American respondents more important than for Russian respondents)
- differences in answers to question 9.1, 9.2, 9.4 (statistic difference value 90%), answers to questions 9.6, 9.8, 9.9 (statistic difference value 99%.

Sequential comparison of the question- answers of the pairs Russia- USA and Russia- Great Britain showed that the answers to the question autonomous technology transfer structure enforcement are identical. At the same time the respondents' answers of these countries were quite different to the following questions - mobilization of financial resources, income increase of staff, realistic financial foresight for universities, accessibility increase of financial resources, reduction of bureaucracy and interaction enhancement between universities and businesses.

Table 9. Positive outcomes of technology transfer for universities

Question	Country	1	2	3	4	5	Russia-USA average rank	Russia-GB average rank
9.1. Mobilization of financial resources $p_1=0.0001$***, $p_2=0.0001$***	Russia USA GB	43.75 4 3	50 4 9.5	0 11 37.5	0 35 37.5	6.25 46 12.5	13.4 43.6 -	11.8 - 30.8
9.2. Income increase of staff $p_1=0.0001$***, $p_2=0.0005$***	Russia USA GB	56.25 2 9	37.5 9 34.5	0 33 37.5	0 29 19	6.25 27 0	13.2 43.7 -	14.5 - 29.5
9.3. Governmental funding increase for on-demand technologies $p_1= 0.2801$, $p_2=0.1336$	Russia USA GB	37.5 21 56.5	31.25 38.5 34.5	18.75 23 6	6.25 5 3	6.25 12.5 0	31.9 38.4 -	28.8 - 22.3

9.4. Realistic financial foresight for universities $p_1=0.0003^{***}$, $p_2=0.0147^{**}$	Russia USA GB	25 8 3	37.5 4.5 28	31.25 49 41	6.25 20.5 22	0 18 6	20.2 41.7 -	17.5 - 28
9.5. Measures in better insight of business concept execution $p_1=0.1471$, $p_2=0.6892$	Russia USA GB	12.5 28 15.5	25 24.5 22	43.75 37 50	0 7 12.5	18.75 3.5 0	43.8 35.1 -	25.7 - 23.9
9.6. Accessibility increase of financial resources $p_1=0.0615^{*}$, $p_2=0.0016^{***}$	Russia USA GB	6.25 38.5 53	43.75 30 31.5	43.75 23 15.5	6.25 5 0	0 3.5 0	45.8 34.5 -	33.6 - 20
9.7. Autonomous technology transfer structure enforcement $p_1=0.4295$, $p_2=0.8415$	Russia USA GB	6.25 19.5 28	25 35 12.5	68.75 28 31.5	0 14 25	0 3.5 3	40.8 35.9 -	23.9 - 24.8
9.8. Reduction of bureaucracy $p_1=0.0969^{*}$, $p_2=0.131$	Russia USA GB	12.5 32 31.5	31.25 34 31.5	43.75 25 34	12.5 7 0	0 2 3	44.8 34.8 -	28.8 - 22.3
9.9. Interaction enhancement between universities and businesses p1=0.0588*, p2=0.1868	Russia USA GB	31.25 56 34.5	31.25 31.5 59	31.25 5.5 6.5	0 3.5 0	6.25 3.5 0	45.9 34.5 -	28.3 - 22.6

The following diagram shows the comparison research analysis results (Fig.1):

Conclusions:

1. Strong similarity in Russian and American respondents' answers can be related to such questions as major motives for universities in technology transfer implementation and key problems of university technology accessibility for business.

In these two cases zero hypotheses is expectable. Thus, the major motives for universities in technology transfer implementation and key problems of university technology accessibility for business are identical for both Russian and American university representatives.

2. Strong similarity in Russian and British respondents' answers can be related to such questions as key problems of university technology accessibility for business, technology transfer barriers in business and accessibility of university technologies. In these three cases zero hypotheses is expectable. Thus, key problems of university technology accessibility for business and technology transfer barriers in business are identical for both Russian and American university representatives.

3. The average statistic value 77% (USA) and 72% (Great Britain) were determined for such questions as basic types of university activities, dimension of organized structure coordination of the universities in technology transfer, major motives for universities in technology transfer implementation and activity rate of technology transfer into business

Zero hypotheses are excluded.

The research target has been achieved and the similarity evaluation including definite statistic similarity value of the respondents' answers has been conducted. It seems advisable to continue research involving the possibility of introducing foreign experience into Russian universities where priori would be the results of this research. In this case, the objective would be to prove or disprove the following hypothesis – based on the question- answers of the respondents stating a "strong similarity" - would it be possible to further the experience of USA and GB universities in technology transfer within the framework of different Russian universities.

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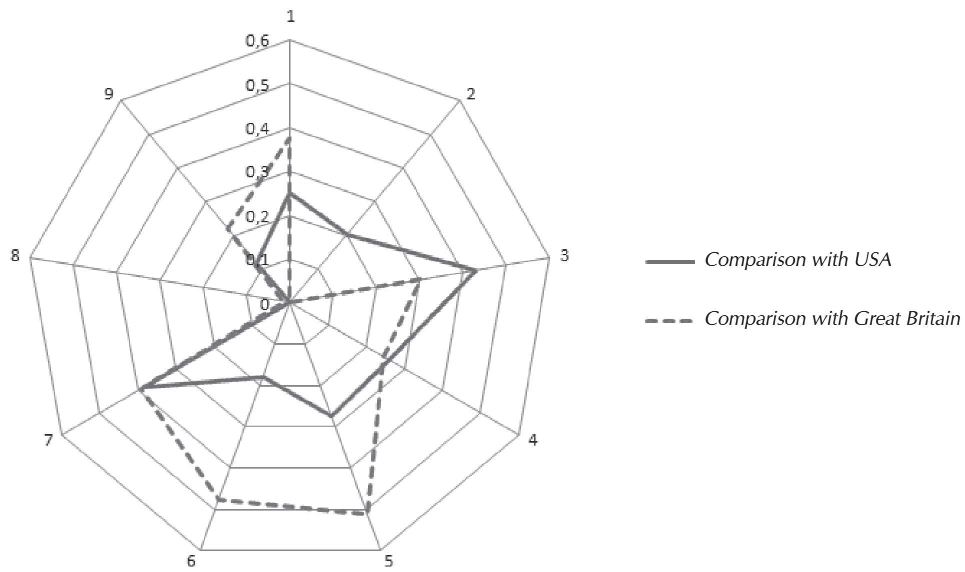
Fig.1. Integrated evaluation of priority problems for Russia, USA and Great Britain



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QUESTIONNAIRE AS A PROSPECTIVE INSTRUMENT OF STUDENT INVOLVEMENT IN RESEARCH

National Research Tomsk Polytechnic University
N.N. Kairova, B.B. Moises,L.M. Zol'nikova

The article discusses the influence of student research activities on higher professional education development. The perspective implementation of questionnaire as an instrument of student involvement in research activities is presented.

Key words: *higher professional education, modernization, National Research University, development indicators, student scientific research, questionnaire, motivation.*

N.N. Kairova

B.B. Moises

L.M. Zol'nikova

Higher professional education is undergoing a process of reform. It concerns not only the transition to the two-level education system and the implementation of the 3rd generation of Federal State Educational Standard but also the modernization of higher professional establishments themselves. A sharp increase in the number of universities, from 762 in 1995 [1] up to more than 3500 in 2012 [2], is a direct consequence of these processes.

Furthermore, not all universities have necessary facilities to meet the current education requirements. In the words of Vladimir Putin: "A growing number of universities observed at the beginning of the 1990th which were focused only on diploma delivery and this fact was already discussed, is useless as it is just profanation of education" [3]. It is obvious that not each university can provide qualitative and purposeful education. This raises the question of whether it is possible to distinguish between "well-deserved" diplomas and just "wallpaper" degrees.

In order to solve the problem of decreasing the number of universities by closing the most "inapplicable", the government is trying to range them by giving different statuses.

Competitive state support of innovative educational programs of higher education institutes within the Priority National Project "Education" (2006-2008) is one of the basic mechanisms to classify a great number of universities. Based on the competition results, 57 higher education institutes were granted financial support ranging from 200 thousand up to 1 million rubles [4] which was intended for the renovation of material and technical facilities required for scientific and academic performance, improvement of computer and methodological resources and insurance of faculty professional development.

Meantime, a number of federal universities, i.e. gigantic scientific-educational centers, have been established by merging the largest universities in the regions since 2007. These federal universities get rather significant financial support from the Federal budget.

In 2009, Russian President Dmitry Medvedev signed a law granting Moscow State University and St. Petersburg State University the special status of a unique scientific and education complex that enables them to develop educational programs based on their own standards and requirements.

A pilot program to create national research universities across Russia has been launched since 2009. Being innovative scientific educational centers, these national research universities getting significant financial assistance are planned to provide Russia's economy with highly-qualified specialists and contribute to the development of Russian science and technology [5].

Thus, the current system of higher professional education is categorized as follows:

- two leaders - Moscow State University and St. Petersburg State University;
- federal universities (8 universities) – large scientific-educational centers in each federal district;
- a number of innovative universities granted the status of "national research" and developed as integrated scientific-educational centers (29 universities);
- innovative universities which have not granted yet the status of "national research" (30 universities);
- other universities which can be divided into state and private universities.

Summing up the current national policy in higher professional education, it can be stated that the development of higher education institutes, which have been granted significant financial assistance, is carried out as part of a larger national effort to modernize Russia's educational system by integrating science, education and innovations.

In addition to, one of the required conditions for the development of higher professional education stated in the Concept of Long-Term Socio-Economic Development of the Russian Federation until 2020 is the involvement of students in research activities, which will allow universities to retain existing scientific schools and raise a new generation of scientists [6].

The influence of research activity carried out by students and young scientists on the development of the universities is an unquestionable fact. To prove this statement it is enough to examine the development program of Tomsk Polytechnic University (TPU) [7,8], specifically the part including the scientific indicators of its efficient implementation, which has been developing as a National Research University since 2009.

The indicators which are influenced by the research activity of students and young scientists are the following:

- percentage of students involved in research activity;
- number of articles on priority areas of research activity published in scientific journals indexed by Russian and foreign organizations (Web of Science, Scopus and Russian citation index);
- number of post-graduate and doctoral students as well as amount of Candidate's and Doctoral dissertations alongside with the sustainable growth;
- amount of research and development works;
- number of foreign forums, conferences, seminars, workshops and expositions with the participation of TPU faculty;
- international forums, conferences, seminars, workshops and expositions on priority areas of TPU development;
- number of students working in the students' business incubator;
- amount of post-graduate students who have undergone an advanced training in the world' leading scientific and university centers.

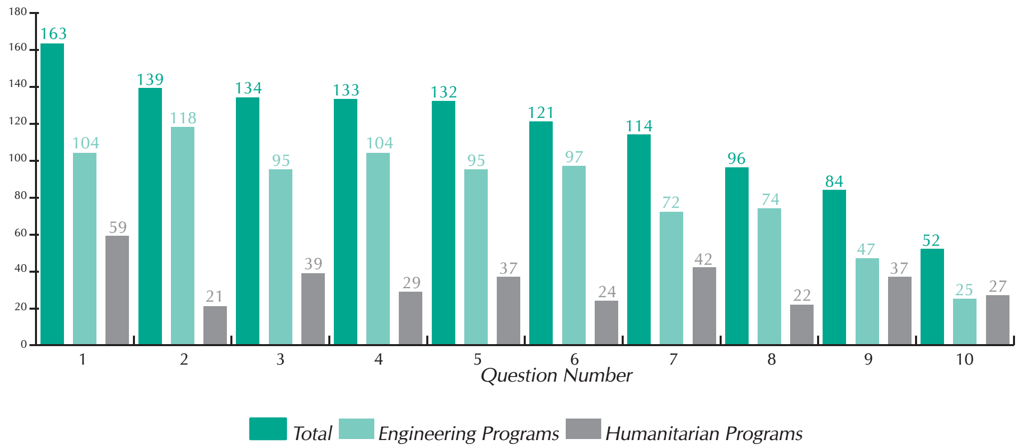
In this article, we will pay special attention to the indicator showing the number of students participating in research activity. By 2018, it is required to reach 75 %. Considering the fact that not less than 11 million of students must be enrolled by 2018 according to the university development plan, 8 thousand of students are required to be involved in scientific work.

To fulfill this plan, it is necessary to apply all possible methods, both direct and indirect, to reveal student's interest in scientific work. Questionnaire is con-

Table 1. Questionnaire Answer Variants

№ пп	Answers
	I category
1	Have a possibility to participate in training, research and fellowship programs
2	Develop research skills
3	Have the proper up-to-date equipment to carry out scientific research
	II category
4	Obtain Enhanced Stipend
5	Get public recognition
6	Have a possibility to acquire and develop additional skills in your free time
7	Gain experience in public speaking
	III category
8	Participate in cultural events
9	Be involved in sport activities
10	Have additional circle of contacts

Fig.1. Student Survey Results



1 - additional circle of contacts; 2 - have the proper up-to-date equipment to carry out scientific research; 3 – gain experience in creative work; 4 – opportunity to participate in scientific advanced training; 5 - possibility to acquire and develop additional skills in your free time; 6 - enhanced stipend; 7 – public speaking experience; 8 –involvement in sport activities; 9 - participation in cultural events; 10 – public recognition sidered to be one of such methods which make it possible to consider the opinions of the whole amount of students.

Therefore, the purpose of this article is to show the advantages of student survey application in order to define their interests and priorities in course of academic period. Based on the obtained results, it will be possible to develop the motivation schemes aimed at attracting students' interest to scientific work and recommendations for further actions.

The investigation was concerned with the analysis of students' motivations in various activities. The survey experiment involved 392 students of Tomsk Polytechnic University (277 first-year students, 104 second-year students, 11 third-year students) who were asked to answer the following question: "What are your priorities in university?" Answering the question it was possible to choose not more than 3 suggested answers.

The proposed questionnaire included the answers (Table 1) which were categorized as follows:

I – answers which reveal students' interest in scientific activity;

II – answers which indirectly reveal students' interest in scientific activity;

III – answers which are not related to an scientific activity – "neutral".

The survey results showing students' priorities are provided in Fig.1.

The obtained data categorized in the basis of the answers are given in Table 2.

Table 2. Survey Data.

№ пп	Scheme	Respondent Number	Answer Categories		
			I	II	III
1	«3-0-0»	15	3	0	0
2	«2-1-0»	64	2	1	0
3	«2-0-1»	38	2	0	1
4	«1-2-0»	43	1	2	0
5	«1-1-1»	94	1	1	1
6	«1-0-2»	20	1	0	2
7	«0-3-0»	7	0	3	0
8	«0-2-1»	55	0	2	1
9	«0-1-2»	51	0	1	2
10	«0-0-3»	5	0	0	3

Thus, respondents can be divided into ten categories.

The first category involves 15 students whose three answers reveal the motivation in research activity ("3-0-0" scheme). In this case, it is possible to assume that they are already highly-motivated and in order to attract their attention to scientific work it is enough to inform them about the basic principles of university research activity and address them to the corresponding designated persons.

The second and the third categories amount the students whose only two answers reveal the motivation in research activity. The main difference between them is that the students from the second category can be motivated by exerting influence on the third priority, which in its turn indirectly defines the interest in research activity, for example seeking for enhanced stipend. It is a well-known fact that in order to be granted this or that scholarship, a student must have significant scientific achievements (awards, publications and so on). In this case, target-focused motivation, i.e. emphasis on the corresponding scholarship rules and regulations, should be applied.

In the third category ("2-0-1" scheme), it is necessary to increase respondents' level of certainty in the importance of scientific activity through the corresponding answers. For example, if a student has chosen the answer "have the proper up-to-date equipment to carry out scientific research", the access to the required equipment allowing him to conduct real scientific work must be provided.

The next three categories involve the students whose only one answer reveals the motivation in research activity. The fourth category involves the students whose two answers indirectly reveal their interest in scientific work, while the students in the fifth category have chosen only one answer showing their motivation in science.

These students can be motivated by "public recognition". For example, to become a winner in the competition "The Best Student of TPU" or receive the scholarship of the State Duma of Tomsk region it is required to have good academic and scientific achievements. As a rule, the photos of the winners of the first competition ("The Best Student of TPU") are placed on the university Honors board, while the pictures of the State Duma Award holders are posted on the publicity board in the centre of Tomsk.

If student's priority is somehow connected with getting experience in public speaking, he/she can be easily motivated to take part in various scientific conferences of different levels (university, regional, Russian and international) which can be held not only in Tomsk but also in other cities and even foreign countries.

Thus, it can be stated that it is possible to select a definite motivation scheme for each category of students. These motivation schemes are still being developed and can be implemented only through practical recommendations.

To sum up, a student survey (especially at the first stage of education) aimed at the analysis of students' priorities in the course of academic period and serving as an instrument of student involvement into research activity will make it possible to:

- define student motivation in research work;
- develop the recommendations on attracting more students to scientific activity.

The next stage will be the development of action plan and practical recommendations aimed to increase contribution of students and young scientists to the development of the university itself.

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INTERNATIONAL COOPERATION IN VOCATIONAL TRAINING

Kuzbass Regional Institute of Vocational Training Development
Ye.L. Rudneva, M.P. Pal'yanov

The article deals with the problems of theory and practice in international cooperation for increasing the graduates' competitive ability of vocational training institutions in Russia on the basis of implementation of adapted potential of international cooperation foreign experience in vocational education.

Key words: *international collaboration in professional education, adapted international professional education experience, integration of Russian professional education into international educational community, background and perspectives in professional education collaboration between Russia and America.*

Ye.L. Rudneva

M.P. Pal'yanov

At present the importance of in-depth comparative investigation of foreign advanced educational practices and their interpretation in terms of Russian higher education has increases. From our point of view, the potential of comparative and international education has not been sufficiently used for development of national educational policy.

In the course of investigation the international organizations reports were used (UNESCO, CEDEFOP, ILO, OECD, World Bank, European Council, European Training Foundation etc.); scientific literature in vocation and personnel training (Cramer S., Herr E., Kutscha G., Plant P., Super D. and others); analysis of more than 50 periodicals including international ones: «Comparative Education» (London. UK); «Journal of Philosophy of Education» (Oxford. UK); issues of Comparative and International Education Society «Comparative Education Review» (Chicago, IL. USA) and so on; American: American Association of Educational Research «American Educational Research Journal» (Washington, DC); «Journal of Vocational Behavior» (Orlando, FL) and others; German: «Die Berufsbildende Schule», «Pedagogische Rundschau» and others, as well as Internet databases on vocational, engineering training and training for ERIC career, Web-pages of numerous training institutions; researches of Russian scientists in vocational training structures in the countries involved, results of international educational projects in this field.

Nowadays, structure of general and vocational education has lost one of its major achievements – providing students with fundamental knowledge, development of their creativity. This fact is shown by the assessment results of training level of Russian university applicants. Secondly, the period of vocational training is reduced in Russia; there is no interaction in all levels of vocational training and industry that results in failure of native higher education to provide recruitment needs of labour market. It should be mentioned that in the modern world there is a tendency to increase but not decrease the term of apprenticeship in the structure of basic and vocational training. In general, basic education lasts 12–13 years, but in Russia only 11. The same tendency is peculiar to vocational training. For example, in the USA there is the system of vocational training «2+2+2»: elementary education lasts 2 years, secondary – 2 years and highest – 2 years. In Germany training at higher vocational training institutions lasts from 6 to 7 years.

Of particular interest is the experience in a number of international educational programs. Among them there is Russian-American program «Education. Business» initiated by the Center of Education and Training for Employment, the Ohio State University and a group of researchers-teachers from Moscow, Kazan, Novosibirsk, Tomsk, Barnaul, Khabarovsk, Kemerovo and other cities in 1990.

The team of researchers, managers, lecturers as well as businessmen was formed; they became permanent participators of the program. The Center of Education and Training for Employment, the Ohio State University (professor Chester K. Hansen, a supervisor of Russian-American program), having significant experience in international educational project implementation, presented a set of documents necessary for opening and working of joint schools, found partner school – Engineering Center Tolls in Plain city, Ohio, found sponsor for support of school with newest academic literature – «Glenco» edition, MacMillan – Macgro-Hill department.

In 1990–2001 Russian-American vocational schools, vocational centers and colleges of Ohio, Oklahoma, Visconti, Alaska worked as partners. There were issues of journals «Education. Business» (Russia) and «New Careers» (USA). Training of RAVS students and teachers was arranged in Tomsk, Yakutsk, Omsk, Barnaul, Khabarovsk, and Kemerovo and in partner-schools – Engineering Center Tolls in Plain city, Ohio and in Engineering college of Waukesha county, Visconti (residence in the USA was at the expense of American partners). The delegation exchange was based on self-funding. Continuation of co-operation and experience exchange among RAVS partners is supposed via seminars and training courses. In total, nearly 2000 Russian students and teachers, 150 lecturers were trained in the USA.

The results of research are publication of multi-author international monographs «Modern Tendencies in Vocational Training Development», «Comparative Analysis of Vocational Training Systems in Russia and Abroad: Structure, Organization, Content and Assessment», «Vocational Training in Russia and Abroad»; arrangement of experimental grounds in educational institutions of different types to study the problems of graduates' vocational training and their participation in educational programs in Russia and the USA; arrangement of language practice for students from Russia and the USA; arrangement of elective courses «Career Planning», «Development of Students' Value System», «Communicative Culture» based on the foreign experience.

In the course of comparative-pedagogical research the educational potential of foreign experience in vocational and engineering education is implemented (colleges and universities of Ohio, Michigan, Indiana, North Carolina) in the system of Russian Education. The dual system of engineering training is applied (Yurga Engineering Institute, TPU and Oldenburg University, Germany) for innovative production [1]; technique of bicultural education (kindergarten – elementary school "Cristina" complex, Tomsk) is used in cooperation with organization «Senior Experts' System» (Bonn, FRG). Experience of resource centers (on the basis of adapted experience of educational institutions of Great Britain (Eastern Birmingham College, Central Collage Wirell)) is introduced in the institutions of secondary and higher vocational education in Siberian region (Tomsk, Kemerovo, Omsk).

The most significant difference between native and foreign educational systems consists in the fact that students of eastern secondary schools, in addition to general secondary education, get initial vocational training. Every American school has training centers where students are trained in various jobs. The center facilities are funded by the enterprises which are potential employers for the graduates. In Germany the places for pupils to study are given directly at the enterprises. At present in FRG there are about 550 thousand of working positions for pupils at the enterprises where the basic vocational training is performed under a master's supervision. In this case the basic vocational training is supported both by employers and the government.

Another important problem of domestic education is the fact that professional training at senior secondary school does not assist in pupils' vocational self-identification and is only aimed at additional enhanced studying of this or that academic majors. There are not any engineering or vocational profiles in schools, cooperation between school and enterprise is absent, as a result of which the latter does not participate in development of school's material and technical resources. The item of vocational training is extremely significant for our country. Today vocational education in Russia is reduced to in-depth study of definite subjects. But in eastern countries vocational training includes by all means vocational and pre-vocational training, i.e. preparation for professional activity and implies the beginning of professional career formation, sustainable vocational self-identification. According to the data of our research, only 40–45 % of secondary school leavers are ready for choice in professional career [3].

It is paradox that Russian school-leavers having passed USE (Unified State Examination) have the right to enter domestic university of any profile, whereas abroad in order to enter university of definite profile a school-leaver is to apply certificate of vocational training relative to the university profile and portfolio with achievements in the sphere relative to the university profile in addition to secondary school certificate. In the system of Russian higher education it influences negatively the pupils' vocational self-identification and motivation for study and vocational activity as well as the quality of their preparation for entering vocational university [1].

The alarming symptom is youth unemployment growth particularly among the graduates from secondary and higher vocational institutions [2]. According to the data of employment center (EC) of Siberia, the youth unemployment amounts 25-30 %. Therefore, there appears the need for registering some standards of youth employment government regulation in law.

In cooperation with state employment centers in Siberia area we are investigating the problems of youth unemployment that, according to the data, is still growing. One of the basic reasons for this is reduction of the number of elementary, secondary and higher vocational educational institutions (if 7 years ago 1,5 mln. students were trained in domestic institutions of basic vocational raining, now they amount about 400 thousand). Suppose previously the Russian institutions of higher vocational training cooperate with services responsible for graduates' employment, now the graduates have to search for jobs by themselves. Unfortunately, in the structure of Russian vocational education there is no complete interaction system of training institutions and employers. There are no legislative regulations for youth employment by employer. At present, as a rule, students' internship is not arranged at the enterprises. In this aspect the experience of Novosibirsk Installation College and employers' cooperation in arrangement of training center is rather interesting. Here the enterprises deliver modern equipment and technologies for construction, installation and low-height housing construction and provide vacancies for students and graduates of college. There appears a demand for development of new mutually beneficial relationship between training institutions, employers and regulatory bodies to solve the problem of youth's employment, the graduates of higher vocational training institutions, in particular. In the course of joint investigation in the given problem definite positive experience has been accumulated.

Nowadays, there is a problem of labour scarcity in specialists with secondary vocational training at the domestic labour market. Solution of this problem consists, first of all, in development of basic vocational training system, but not in its reduction or inclusion of basic vocational training into enterprises. The system of basic vocational training in Russia is to be incorporated into the system of secondary and higher vocational training in accordance with international tendencies. Besides, it is necessary to reach the prevalence of students' number in the basic vocational training system over their number in secondary and higher vocational training systems. At present comprehensive secondary schools in Russia are mostly focused on preparation of pupils for university entering, where about 80% school-leavers enter, whereas in the USA the part of university entrant school-leavers amounts 44%, but in Germany – 38%. Besides, after graduation from university more than 50% of Russian graduates do not work in their speciality [2].

The quality of vocational training is determined, first of all, by students' individual abilities and their motivation for vocational training that is necessary to take into account at enrollment into vocational training institutions apart from USE results.

Therefore, the significance of research practical resource centers development is growing. They are to integrate pilot training institution. The cooperation of theoreticians and patricians engaged in study of vocational training problems as well as teachers from different regions among themselves and with their foreign colleagues contributes to the development of vocational training system modernization in Russia and enables its further integration into international education cooperation.

One of the important problems is improvement in quality of competitive specialists' training, particularly graduates of secondary vocational institutions, the solution of which is teaching staff qualification upgrading and re-training.

To solve this problem the international program «Education and youth employment in Russia and abroad» has been developed in association with Institute of Theory and History of Pedagogy of RAE (Moscow), Kuzbass Regional Institute of Vocational Training Development (Kemerovo), Research Institute of Vocational Training Development (Moscow), Department of Organization and Technology of Higher Vocational Education (Tomsk Polytechnic University) and western Michigan University (USA), Munich Engineering University (Germany), Harbin Engineering University (China). Within the framework of the given project the colleges are created in Siberian region where students are trained in curricula approved by the foreign organizations: «Qualification Upgrading at the Enterprises», «Management in Research-Educational» and «Leader of Training». Performance of every program is accompanied by receiving of corresponding document (certificate). Both Russian and foreign specialists take part in the process of training. In this aspect the experience in drivers' training is interesting in Kemerovo Vocational Engineering College, Tomsk Design and Service College, Novokuznetsk Information Vocational College, Belovo Engineering College etc.

At present the issue on possibility of internship in a number of foreign companies is being discussed (car service, service and design, construction etc.).

Hence, the multi-functional foreign center of applied qualifications is established that will allow teachers of secondary vocational training to enhance their job. In Siberian region experimental grounds are formed on the basis of RAE and Kuzbass Regional Institute of Vocational Training Development for performance the main tasks of the program (establishment of training centers in innovation technologies, students' and graduates' employment, production internship and teachers' qualification upgrade at profile enterprises, development of conditions for students to receive versatility training or additional qualification etc.).

Adapted training potential of the foreign countries' experience in the sphere of vocational training aimed at integration of Russian education into international educational cooperation is determined by the relationships of global tendencies and regional (national) peculiarities in development of training systems to employment; general approaches to modernization of organizational and didactic bases of lifelong vocational learning both at concept and institutional levels; reality and technology of foreign pedagogical innovation transfer stated in the process of research in the conditions of Russian education.

Support of vocational training institutions as a unique system of lifelong learning with prolongation of academic period, enhancement in vocational training is a perspective way to the sustainable development of the Russian society.

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The Current State of Engineering Education. A View from the Region

North-Eastern Federal University named after M.K. Ammosov
Ye.A. Arkhangelskaya, S.G. Antsupova

The article deals with the key problems of higher engineering education system at the regional level. The ways of their solution are discussed.

Key words: *engineering education, education modernization.*

Ye.A. Arkhangelskaya

S.G. Antsupova

The North-East of the Russian Federation (the Republic Sakha (Yakutia), Kamchatka Krai, Sakhalin Oblast, Chukot Autonomous Area) is referred to rapidly developing regions of Russia. Strategic significance of this region for Russia grows repeatedly due to the economical, demographic, and political processes taking place intensively in the world and in the adjacent areas in particular.

According to the complex scheme of production force, transport and engineering development and distribution of Republic Sakha (Yakutia) the economic development is aimed at its diversification, formation and development of recycling production, development of regional fuel engineering complex up to national scale in the Far East of Russia and international scale in the whole North-East of Asia till 2020 [1].

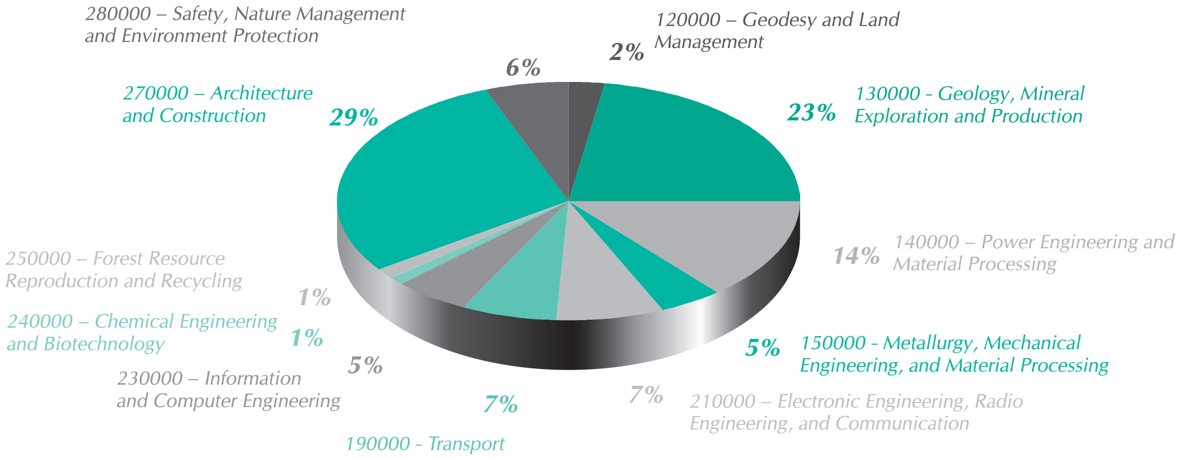
One of the ways, currently accepted as a perspective one, is intensification in integration of higher educational institutions into the region activity on the territory of which they are located. In other words, training students is to become advanced to implement modernization and engineering development of the real regional economics. Therefore, the role and significance of engineering education system increase in particular as a power of innovation economic national system in Russia.

The head university training specialists for North-East region of Russia is the North-Eastern Federal University named after M.K. Ammosov (NEFU), where more than 22 thousand students are trained. The part of engineering specialities amounts 30%, there is a growth of students' number in engineering profiles, new specialities and profiles were opened within the last 3 years: petroleum engineering, chemical engineering, land management and register. Realization of 11 consolidated profile groups (CPG) in engineering training shows the regional peculiarities, namely, demand for engineers of construction and mining-geological industries (Fig. 1).

The NEFU development program of 2010-2019 with financial plan adoption for 5 years (1 billion per year) has provided the new conditions and perspectives for the university itself. Much has been done by now: there appeared new departments, Arctic innovation center (AIC) was established, 12 small innovative enterprises were set up, and the research-training infrastructure is being sufficiently modernized.

In the course of strategic tasks the direction «Modernization in Content and Organization of Training Process with Regard to International Tendencies in Development of Education Techniques and Technologies» is defined as a condition for providing education quality, allowing the graduates to be competitive

Fig. 1. The relationship of the Students' Share in CPG as of 31.12. 2011



in the modern labour market in social sphere.

Solution of the given problem is directly connected with the adoption of two-level training by the university. Much has been done, transformations were introduced into university management, material-technical, and financial systems. However one cannot be satisfied with the achievements. The transition into two-level education system is connected with the necessity of taking into account some important factors.

Firstly, management and teaching staff readiness for development of conditions for transition of training departments to level education.

Changes in organization of educational process is revealed in the fact that the main thing becomes students' choice – the choice of curriculum, sequence in studying subjects, selective courses, lecturers, development of individual syllabus. Hence, the task of university is to provide such a choice. Such an approach allows student to choose the level of proficiency that corresponds at the moment to his (her) wish, possibilities and skills.

In fact, the tasks of reorganization are complicated and strongly influenced by external factors, archaic principles and the future is too vague to make global programs too efficient. Today engineering education is developing in the condition of out-of-date methodical and academic base, educational structure and content insufficient for its stage-by-stage integration into the international education space.

When developing basic curricula on the basis of FSES, it is necessary to use the principle of «passing through modules» consisting of choosing a number of modules for every curriculum (profiles included in CPG) determined as constituents for achieving one of the generalized goals of training in education program as a whole and providing the formation of both general and professional competencies. Curricula are necessary to be developed on the principle of credit-module system; in this case a module can include subjects from different courses of natural sciences, general professional disciplines the content of which is to correspond to the goals and tasks of the module. Such an approach is aimed at establishment of correct logic sequence in studying disciplines, interdisciplinary links and opportunity to response quickly to the changes forming more specific and rigorous requirements to engineering university graduate.

Secondly, scientific researches are to form the bases for generation of new ideas and their transfer to educational process and economics of the region via innovative activity. Nowadays, researches are often aimed at formal increase in university academic and accreditation indexes, first of all, the number of dissertation defenses and publications.

Primarily, only in case of arranging profound scientific training through Master course one could train elite engineers, highly-qualified technicians and managers, encouraging and motivating the training of scientific-pedagogical human resource through post-graduate and doctoral courses. Research activity in university is to have clear structure and distinct system of management. It is necessary to abandon the fragmentation of scientific research, reduction to department-scale in favor of integration of research trends and scales, one should enable the development of interdisciplinary and multidiscipline researches. Of particular importance is also team use of unique and expensive equipment in training masters and post-graduates.

Of great use is to develop basic research laboratories that will become an effective link in the technological chain of receiving the newest scientific knowledge by the students in combination with involvement in real research, on the one hand, and a true foundation for efficient innovation activity, on the other hand.

The reference point in the sphere of scientific research is to become Priority trends in modernization and engineering development of Russia; Priority trends of science, technology and engineering in the Russian Federation approved by RF President on 21, May 2006, № Пр-843; Critical technologies of RF, the list of which was approved by RF President on 21, May 2006, № Пр-842 [2].

In this case one needs to create efficient mechanisms of interaction with academic science and real economic sector of the region. We realize that contemporary research should form opportunities for additional fund raising in university.

Under the condition of absence of legislative and financial mechanisms for encouragement of universities' innovative activity, stimulation and preference system for attraction of private investments to establish small innovative enterprises, to introduce new technologies into current production, commercialization of research results a regional university has to be a centre of business, society, state communication in questions of forecasting scientific development, investigation of world technological market, solution of global problems. To perform the innovation activity special groups should be formed (for example, as a part of NEFU Arctic Innovation Center) that are directly engaged in research of engineering development, scientific-technological forecasting, are the resource centers for enterprises and companies of the given region performing consulting and informative-analytical activity etc.

Thirdly, a distinctive feature of regional universities has been a practice-oriented direction in students' training. Today engineering training is performed at insufficient participation of employers without efficient practical training at base regional plants, legislative and financial problems of regional university and plant interaction are not solved. Current curricula are not sufficiently adapted to the conditions of market relation and not always make possible for students to have efficient practical training. According to employers' estimation, if the level of students' theoretical training is estimated comparably higher, then poor graduates' practice orientation cannot satisfy them.

It is necessary to bring into accordance the content and structure of professional education and labour market demands. In particular, one should improve sufficiently the practice arrangement and content, enhance the practical orientation, involve leading specialists and managers into classes, organize and conduct practical classes at the enterprises of different property forms.

It its turn, the sphere of professional training has always additionally required academic, laboratory and supplemental facilities. It is necessary to involve industrial plants, research institutions, experimental workshops into educational activity on the basis of private-state partnership, to establish design bureaus, special technology development economic zones, training-experimental plots, remote laboratories etc, introduce the network of educational program performance.

Along with increasing requirements for graduates' competencies a number of principle problems are posed the essence of which consists in contradiction between the necessity in sufficient growth of graduates' knowledge, skill and competence level and ambiguity in methods and means for reaching this level [3]. For example, lecturers' qualification upgrade or students' practical training by means of their internship at construction enterprises allows them to find their positions in terms of employers' requirements and opportunity to learn new equipment and tools which they are going to work with. But nearly entire material-technical base of construction industry is in stagnation and requires sufficient modernization and adaptation to modern economic market and new tendencies itself. In this case the speech is about modernization, perspectives, advanced training of personnel. Today this issue needs to be specially considered as modern engineer cannot be trained without appropriate facilities.

There is no governmental regulation obliging employers of enterprises, companies, institutions, private firms to take students for internship, to provide them with work places and rights equal to members of work team, to perform mentorship. At present, not all employers are interested in arrangement of internship at their companies since this responsibility requires additional resources, time for management and mentorship, resources which are limited for enterprise. There is no purpose governmental funding for this sphere of employers' activity.

Hence, assessment of internship results can allow for evaluation of students' competence development, but only in case if the internship itself is performed at the appropriate level: correctly selected practice base, qualifies specialists work as consultants from university and enterprise, students themselves work at up-to-date equipment and are involved in true projects.

One of the serious problems connected with changes in the labour market is a threat of graduates' unemployment or work not within their specialty. Graduates like young specialists appear to be one of the most vulnerable population group in social aspect, apparently without relative governmental support, legislative mechanisms of social support for a young specialist, the problem cannot be solved by only one university. Nevertheless, the problem of employers' involvement into graduates employment activity and their adaptation at production has become one of the highest priorities for universities. For example, to assist in graduates' employment, encourage career planning and development; arrange students' temporary employments the Career Center of NEFU was established, the vacancy fairs are held. Nevertheless, enterprises and companies are poorly involved in this sphere as economic conditions for their participation are absent. It is necessary to organize perspective cooperation of university with enterprises and plants interested in graduates. Under these conditions one should create special structures within the universities that are to be purposely engaged in employment, under the condition of market relation the new approaches and economical means for solution of problem in their stimulation (funding) are required in this case. Today the responsibility in employment assistance is an extra-job for the workers of graduate departments, not included in the load and because of this performed without necessary planning and not efficiently.

In the course of this activity it is useful for universities to learn to forecast the demand for specialists of this or that profile at both short-term and long-term scale and to respond to it by changes in curricula and syllabuses.

Fourthly, extended education in universities is often centrally managed resulting in isolation from production and consumption demands, becoming less attractive from the point of view of business investments. It is mostly expressed in professional engineering education. It is typical for it the absence of efficient stable direct and reversed feedbacks with production enterprises, absence of industrial units' interest in the system of extended education. At present extended education being an important part of continuous education is intended to respond to new requirements of regional economics, growing demands of society for qualification and professional training rapidly and efficiently. First of all, development of extended professional education system would promote the creation and operation of engineers' certification system. The mass training and re-training of qualified engineers and technicians is necessary via the system of extended education, first of all, via synergetic partnership with industrial companies [4]. One needs to increase the attractiveness of extended education for labour market, correspondence of content and quality of educational services to the industrial requirements. Besides, it is essential to involve leading regional industrial plants into training process using their production and innovation potential and in co-operation to establish industrial centers, engineering certification systems.

Fifthly, a serious problem remains in absence of developed systematic task-oriented work with gifted children and talented youth to prepare them for entering engineering departments. A rather heterogeneous cover of schoolchildren with extended curricula should be noted. In rural areas its complete absence is observed. In this situation it is necessary to use advantages of regional university in closeness to entrants, efficient mechanisms of bright school-leavers' selection as well as opportunities of research and specialized educational institutions such as physical-mathematical forum «Lenskiy Krai», Small Engineering Academy. In NEFU the system of network communication with educational institutions of Far-Eastern Federal District is being formed. One of the forms of network cooperation is association «North-Eastern University Educational District» that incorporates 56 training institutions of different types in the Republic Sakha (Yakutia), Magadan Oblast, Sakhalin Oblast, Chukot Autonomous Area. A union of university, schools, professional education institutions permits, on the one hand, openness, accessibility and variability of education both in republic and in the whole region, succession of secondary and higher education.

Finally, in terms of new economical relations, humanity and flexibility of education system it is required to introduce some corrections into conceptual principles of education system, lecturer's attitude to a student. To develop conceptual principles it is necessary to take into account the economic approach, to involve students and their parents, employers into educational process as consumers, clients. Now a student is transformed from «raw material» into «consumer», from an object into subject of training, becomes a participator of training process formation.

Administrative approach to the education quality in the course of which the quality was defined by examination session results as a level of student's standard proficiency, but those who did not pass exams were sent down without mercy from university has become outdated. Following the real economic sector we must realize that new economical approaches towards education, quality management meeting the demand are required in this condition.

The created situation in the sphere of engineering education has shown the necessity in system to surmount the negative phenomena, principal organizational transformations in the structure of engineering education, enhancement in specialists' training quality in accordance with contemporary social-economical conditions of RF North-East development, requirements of the integrated world educational community and advanced experience of highly-developed countries.

The current problems of engineering education require integrated solution. We see the solution of the problem just in conceptual program development of regional engineering education system. In its development and performance, defining its general strategy, key directions, priorities and tasks universities, authorities, and businesses of the region are to participate.

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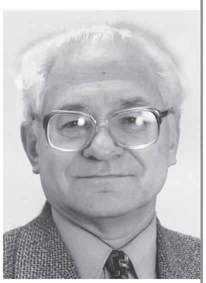
ENGINEERING TRAINING FOR HIGH-TECHNOLOGY SECTOR

Bryansk State Technical University (BSTU)
O. A. Gorlenko, V.V. Miroshnikov

The article deals with engineering training for high-technology sector of Russian economy. It suggests competence model of a specialist, the scheme of professional standard development process, a competence model of a graduate and approaches to the matching of graduate's competences and professional standards requirements.

Key words: *engineer, competence, professional standard, innovation, technology.*

O.A. Gorlenko



V.V. Miroshnikov

The modernization course, which has been chosen by our government lately, is based on innovative development of economy. There are some models of innovative systems in the world. It is a challenge for Russia to choose the model and to develop the methodology of the innovative development.

A model which has been very popular lately has the name "triple helix" [1]. This model ensures the interaction of three basic components of innovative activity: universities – enterprises – state. It is proved that the core of the innovative activity must be a university. The "triple helix" started to be implemented in Russia. The first signs are the innovative system of Tomsk State University of Control Systems and Radioelectronics (TUSUR) and the innovative project "Skolkovo".

Though, there are barriers which are difficult to overcome. They are the following: there is low demand for scientific results in Russian economy, most of Russian enterprises haven't got long-term stimuli for innovative development, the innovative structure in the country is not developed, there is no business culture in higher school etc. To overcome those barriers it is appropriate to change the way of "Triple helix" implementation in Russia by paying more attention to the "Third helix", that is to address to the authority and to use the powerful administrative resources and to strengthen its role in innovative processes. Thus, there appears a concept of "new industrialization" (neo-industrialization) of Russian economy based on domestic high-tech complex development.

The training of engineers for high-tech sector of Russian economy has a lot of problems. The authors of the article consider some of them.

1. Analytical study of the prospects of innovative development of high-tech complex in Russia.

Для определения потребности в соотTo determine the need for the specialists, their competence requirements it is necessary first to study the prospects of innovative development of basic sector of Russian economy. The objects of the study should be the primary information sources:

1. Federal programs and federal program of regional development

funded by federal budget [2]. The programs are subdivided into several directions, for example:

- High-tech technology development: space program, global navigation system, civil aircrafts, broadcasting, marine equipment, nano-industry, electronic component base and radioelectronics, domestic machine-tool construction and others.
- Transport infrastructure: railway transport, roads, ferry, water transport, civil aviation etc.
- Safety: nuclear and radiation safety, state boundaries, destruction of chemical weapons, modernization of the Unified System of Air Traffic, fire safety, the world ocean, exploration of the Arctic and Antarctica etc.

2. Basic directions and ways for further development of high-tech and medium-tech industries in Russia [3]. According to "Rosstat" classification there are the following groups in manufacturing industries.

- High-tech sectors: aircraft production including spacecraft, computing equipment, broadcast and radio equipment production, medical equipment production, measuring, optical equipment production, pharmaceutical products
- Medium-tech industries of high level: machinery and tool production, shipbuilding industry and other vehicle production, chemical production, production of chemical machines and electrical equipment, production of cars, trailers and semitrailers.

The "core" of high-tech and medium-tech industries is a military-industrial complex (MIC). That is why it is necessary to include the annual reports of Russian Technologies State Corporation to the list of the studied objects.

3. The prospects of Russian's transition to the sixth mode [4].

The high-tech and medium-tech industries mentioned above reflect the tendencies of the past rather than the future. These are the industries of the third, fourth and the first stages of the fifth technological mode. It is mostly MIC high-tech enterprises that refer to the fifth one. But the world is working on the sixth technological mode. What are its basic directions? First of all, they are nanotechnology, biotechnology, information and communication technologies and new materials technology. By 2020-2025 there will be a science and technology revolution based on developments synthesizing achievements in basic technologies in the above mentioned areas.

Thus, Russia faces an extremely difficult task – to make a transition to the sixth technological mode without acquiring the fifth one. Can Russia make such innovative breakthrough being in crisis? The analysis made by the Russian Academy of Science (RAS) [4] shows that in Russia there are researches and developments which are breakthrough in all the directions of the sixth technological mode (Fig. 1).

2. Formation of competence models of specialists for neo-industrialization.

It is necessary to form a generalized model of the required specialists for the corresponding industries basing on the results of prospects study of high-tech complex innovative development.

The competence model of a required specialist can be presented as the following sequence [5]:

$$Ms = \{S, A, FA, CF, E, Q, EX\}, \quad (1)$$

where S stands for sector (sphere of professional activity); A – activity type; FA – j-th labour function of activity type; CF – competence to fulfill the j-th labour function; E – educational level; Q – required qualification level; EX – work experience.

The labour functions FA of the competence model of a specialist (1) are a hierarchically connected set (Fig. 2). Labour function decomposition goes on till the final element of the tree becomes an obvious task for a performer.

Every labour function FA of a lower decomposition level corresponds to the competence CF, which presents a set of the following components: FA –labour actions; FK- knowledge; FS – skills; FP – professionalism; FPQ – personal qualities.

Fig. 1. Researches and developments in critical technologies sphere in Russia

Information and communication systems

- software production technologies
- bio- technologies
- intelligent navigation and control system technologies
- technologies of data processing, storage, transfer and protection
- technologies of distributed calculations and systems
- electronic component base technologies

Environmental management

- technologies of atmosphere and hydrosphere monitoring and forecasting
- technologies of resources evaluation and lithosphere and biosphere condition forecasting
- natural and technological disaster mitigation and risk reducing technologies
- recycling technologies
- environmentally sound exploration and mining technologies

Nanosystem and material industry

- biocompatible materials technologies
- membrane and catalyst system technologies
- polymer and elastomer production and processing technologies
- composite and ceramic materials production and processing technologies
- nanotechnologies and nanomaterials
- mechatronic technologies and microsystem technology

Energy and energy efficiency

- nuclear power technology, nuclear fuel cycle technology and nuclear safety technology
- hydrogen power technologies
- technologies of efficient energy transportation, distribution and consumption
- renewable energy sources technologies
- technologies of fuels and energy from organic materials

Living systems

- bioengineering technologies
- biocatalytic, biosynthetic and biosensor technologies
- biomedical and veterinary technologies for human and animal life support and safety
- genomic and post-genome technologies of medicines
- environmentally and resource saving food processing and production technologies
- cell technologies

Transport and aviation and space technologies

- space, aviation and marine technologies of new generation
- new types of transport systems technologies and control
- energy efficient engines and props technologies

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3. Development of professional standards for neo-industrialization specialists.

The competence model of specialists should become a base for developing professional standards in the industries involved in the neo-industrialization. The process of professional standard development is a content specification of the generalized competence model of a specialist (1) according to an engineering position. The process of professional standard development is shown in Fig. 3 [6].

The problem of professional standard formation and its correlation with education standards is very acute nowadays. There is a great imbalance between the employers' requirements to the employees on the one hand and the training quality of higher school graduates on the other hand [7].

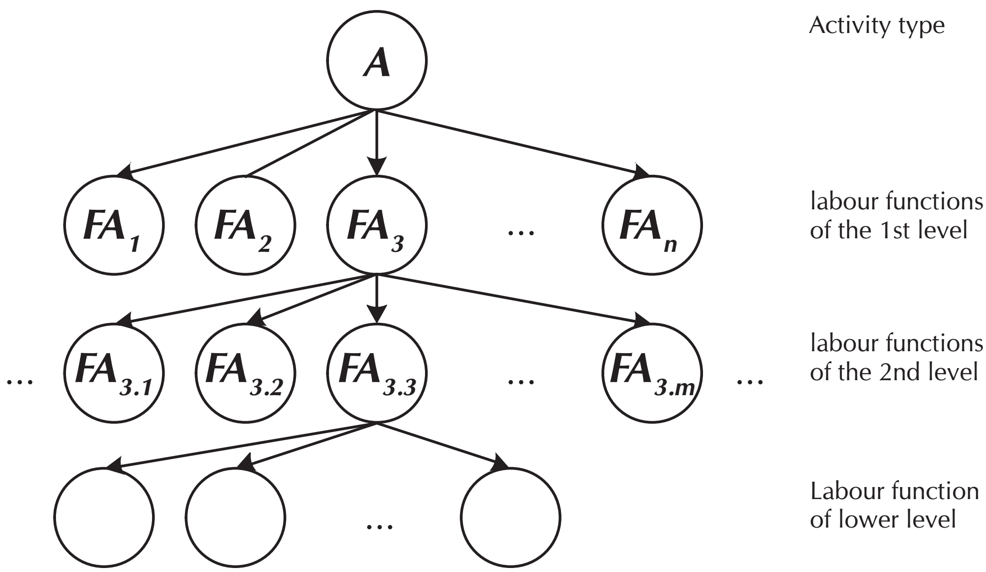
Nowadays the employers' requirements are formed in terms of graduates' skills, abilities, readiness etc. rather than in terms of their knowledge. Practical activities ask graduates not what they know but what they can do and how they act in standard and non-standard situations of professional life. We mean that knowledge as a result of higher education is necessary but insufficient for the required educational level. Professional knowledge should be a part of professional competencies.

4. Coordination of graduate's competencies with professional standards requirements.

With three-level educational system (bachelor, specialist and master degrees) there appears a problem of requirements coordination. These are the graduates' competencies determined by Federal State Education Standards of Higher Professional Education (FSES HPE) and the future job requirements.

To coordinate the graduates' competencies with a competence model of a neo-industrialization specialist (1) and with corresponding professional standard is suggested us-

Fig. 2. Hierarchical block diagram of labour functions of the competence model of a specialist



ing a competence model of a graduate [7]. Its scheme is shown in Fig. 4.

This scheme shows all the training result elements according to the Federal State Education Standards of Higher Professional Education (FSES HPE) starting from the training direction (TD) up to the complex: knowledge (K) and skills (S).

Practical comparison of the competence models of the specialist with the competence models of the graduates (Fig.4) in different engineering training directions showed great differences between them – a lot of competences required by employers are absent in FSES. To solve the problem the authors suggest [7]:

- using methods of formation of the variable part of the basic education program (BEP) which makes possible to take into account employers' requirements;
- organizing further professional training of engineering bachelor graduates.

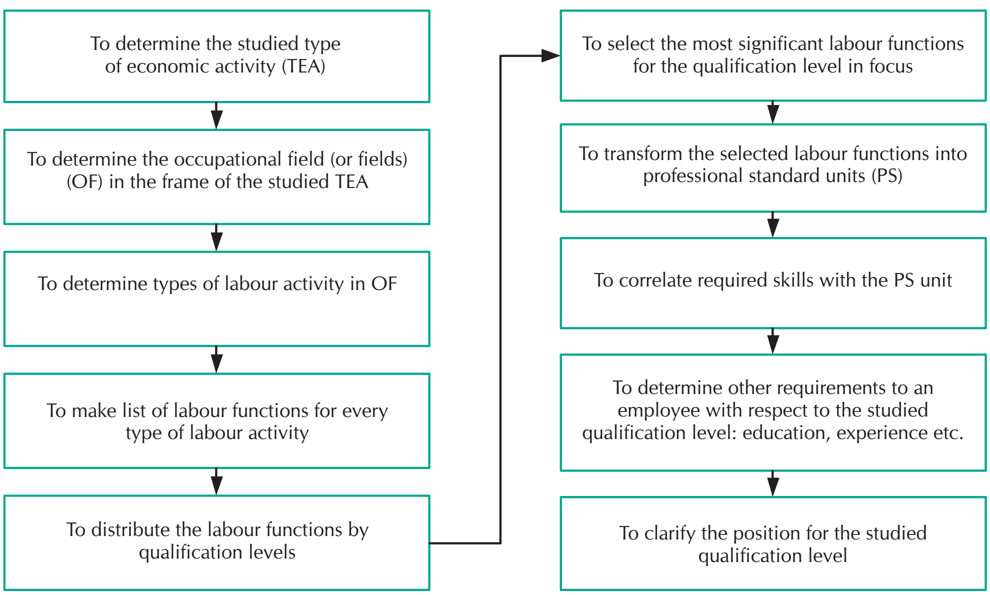
5. Quality – conceptual framework of high-tech industries.

Измерение качества продукции, плaProduction quality measurement, planning, improving and quality management are integral parts of high-tech production management. That is why the quality management engineers (quality management, standardization and metrology) can be regarded as universal specialists of Neo-industrialization economy. Thereby, the experimental test and the implementation of the suggestions mentioned above were done by the authors with quality engineers.

Using the competence model of the specialist (1) a competence model of the quality engineer was developed in BSTU [6], a part of which is shown in Fig.5. This figure shows the implementation of the scheme (Fig.2) in the form of labour function decomposition of the quality engineer for A – activity in quality management system (QMS).

Besides, the quality engineer's competences were determined which

Fig. 3. The development of professional standard content



is necessary to fulfill the corresponding labour functions of the lower level shown in Fig. 5 [6].

Basing on the model (Fig. 5), using the results of employers' survey and taking into account the requirements of Qualification schedule the professional standard for the position "quality engineer" was developed [8]. It determines the following:

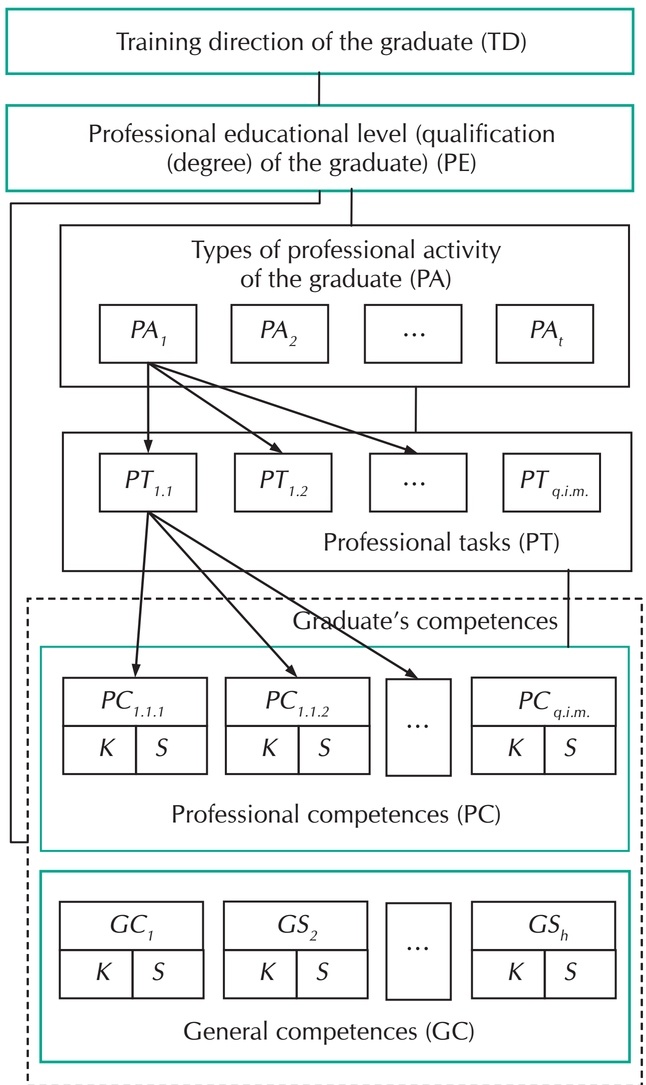
1. Type of economic activity (occupational field).

2. Type of labour activity and its connection with existing regulations.

3. A card of labour activity type that contains: a full title of labour activity type; qualification level; possible job titles, general description of labour activity, possible workplaces, work conditions, professional; education requirements, a list of professional standard units.

4. The description of all the professional standard units each of which

Fig. 4. Block diagram of a competence model of the graduate



contains the following: unit name; basic labour actions; labour means; labour objects; qualification level characteristics (irregularity, responsibility, independence); knowledge needed; necessary skills.

The bachelor and master competence models were developed to make agree graduates' competences with professional standard requirements according to the scheme (Fig.4). The assessment methodology for Bachelor and Master Degrees in quality management (direction 221400) with professional standard requirements for "Quality engineer" was developed [8].

We discussed only some of the problems connected with engineering education for high-tech industries of modernized Russian economy. But the information given in the article can serve a basis to form a training program for future engineers who will be able to implement the projects of the country's neo-industrialization.

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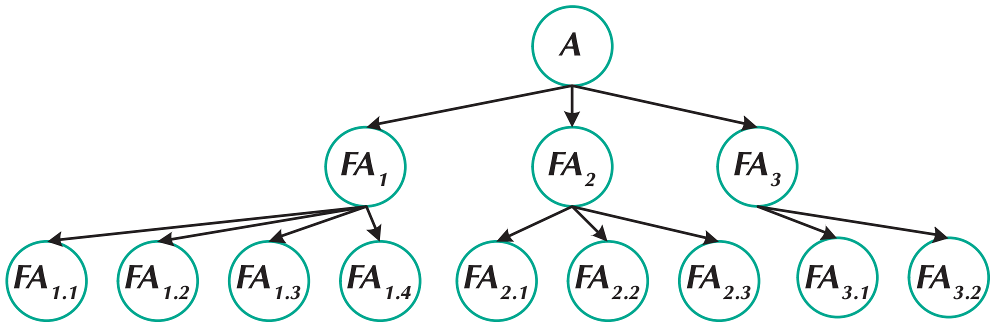
Fig.5 . Hierarchical block diagram of labour functions of the quality engineer



FA_1 – participation in organization, management and control of the enterprise's QMS: $FA_{1.1}$- to take part in QMS creation and development planning, $FA_{1.2}$ – to take part in development and improvement of QMS documentation, $FA_{1.3}$ – to take part in management of processes in the enterprise, $FA_{1.4}$ – management of quality activities; FA_2 – studying, analyzing and improving the enterprise's QMS: $FA_{2.1}$ – to organize and manage the QMS internal audit, $FA_{2.2}$ – to collect and analyze data about QMS functioning, to develop recommendation on its improvement, $FA_{2.3}$ – to manage the actions on QMS improvement; FA_3 – to communicate with external organizations: $FA_{3.1}$ – assessment activities on QMS, $FA_{3.2}$ – to interact with a customer representative.

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Our authors

BORIS L. AGRANOVICH
Candidate in Technical Sciences; professor in Department of Control System Optimization, Institute of Cybernics, Head of IT Department of Higher Education Institution, National Research Tomsk Polytechnic University, Vice-president of AEER, Honorary fellow of RF Higher Education Institution, laureate of President Award in Education.
E-mail: agroboris@ramber.ru

MARINA V. AKULENOK
Candidate inTechnical Sciences; Associate Professor in Quality Control Department, Applied Information Technology Faculty, National Research Moscow Institute of Electronic Technology (Technical University), Honorary fellow in Higher Professional Education.
E-mail: amv@s2q.ru

EVGENY O. AKCHELOV
Master student in Department of Management and Technology in Higher Professional Education, Institute of Engineering Entrepreneurship, National Research Tomsk Polytechnic University.
E-mail: seismopro@tpu.ru, dwrkin@gmail.com

GENNADY V. ARKADOV
Candidate in Technical Sciences; Candidate in Economics; CEO of All-Russian Scientific- Research Institute for Nuclear Power Plant Operation; Head of Physico-Technical Computer Science Department, Moscow Institute of Physics and Technology (State University).
E-mail: vniiaes@vniiaes.ru

EKATERINA A. ARKHANGELSKAYA
Candidate in Technical Sciences; Associate Professor in Department of Expertise, Management and Cadastral Register, Engineering-Technical Faculty,North-Eastern Federal University in Yakutsk, Expert in professional education of Sakha (Yakutia) Republic.
E-mail: e_arkhangelskaya@mail.ru

SVETLANA G. ANTSUPOVA
Candidate in Technical Sciences; Associate Professor in Production of Construction Materials, Items & Constructions Department, Engineering-Technical Faculty, North-Eastern Federal University in Yakutsk, expert professional education of Sakha (Yakutia) Republic.
E-mail: anzupowasg@mail.ru

VICTOR K. BATOVRIN
Candidate of Technical Sciences; Professor; Head of IT System Department Moscow State Institute of Radio-engineering Electronics and Automation-MSTU MIREA, Professor of Department of Business Information Systems, National University of Science & Technology "MISIS", Honorary fellow in Russian Higher Education.
E-mail: batovrin@mirea.ru

OLEG A. GORLENKO
Doctor of Technical Sciences, Professor, Vice-rector in Quality and Innovation; Head of Quality Management, Standardization & Metrology Department, Bryansk State Technical University, Honored scientist of RF; Honorary fellow in RF Higher Education Institutions.
E-mail: goa-bgtu@mail.ru

VALERI V. ELTSOV
Doctor of Technical Sciences, Vice-director of Mechanical Engineering Institute,Togliatti State University.
E-mail: VEV@tltsu.ru

SOPHIA L. EREMINA
Doctor of Economics; Professor in International Management Department; lead researcher of Research Laboratory in Management Processes within Modern Higher Education Institutions, National Research Tomsk Polytechnic University.
E-mail: esofya@tpu.ru

LUDMILA M. ZOLNIKOVA
Head of Student and Young Scientist Research Planning Department, National Research Tomsk Polytechnic University.
E-mail: Natkair@tpu.ru

NATALIA N. KAIROVA
Expert in R & D Department, National Research Tomsk Polytechnic University.
E-mail: Natkair@tpu.ru

NIKOLAI M. LARIONOV
Candidate of Technical Sciences; Professor of Industrial Ecology Department, Intellectual Technical Systems Department, National Research University of Electronic Technology (Technical University), Honorary fellow of Higher Professional Education.
E-mail: lnm@miee.ru

VICTOR I.LIVSHITZ
PhD, Lecturer in Ben-Gurion University of the Negev, Beer Sheva, Israel.
E-mail: viclivsh@bgu.ac.il
E-mail: viclivsh@bgu.ac.il
VYACHESLAV V. MIROSHNIKOV
Doctor of Technical Sciences, Professor in Quality Management, Standardization & Metrology Department, Bryansk State Technical University, Honorary Fellow of RF Higher Professional Education.
E-mail: g70@yandex.ru

BORIS B. MOISES

Candidate of Technical Sciences, Associate professor in Department of Automation and Robotics in Mechanical Engineering, National Research Tomsk Polytechnic University.

E-mail: mbb@tpu.ru

MIKHAIL P. PALJANOV

Doctor of Education, Professor, Head of the Laboratory "Comparative Analysis of Professional Education Systems in Russia and Abroad".

E-mail: krirpo@krirpo.ru

SERGEI A. PODLESNY

Member of AEER Executive Board; Professor, Rector-Consultant of Siberian Federal University.

E-mail: spodlesnyi@sfu-kras.ru

MARINA V. POKROVSKAYA

Senior teacher, Deputy- Head of Designing and Technology of Radio-electronics Systems, Moscow State Institute of Radio-engineering Electronics and Automation – MSTU MIREA, Honored Radio-Operator of Russia.

E-mail: mar-pokrovskaya@yandex.ru

YURI P. POKHOLKOV

Doctor of Technical Sciences, Professor, President of AEER, Head of Department of Management and Technology in Higher Professional Education, National Research Tomsk Polytechnic University.

E-mail: pyuori@mail.ru

ELENA L. RUDNEVA

Doctor of Education, Professor, Rector of Kuzbass Regional Institute of Professional Education Development.

E-mail: krirpo@krirpo.ru

ALEXANDER S. SIGOV

Doctor of Physics & Mathematics, Professor, Fellow of RAS, Rector of Moscow State Institute of Radio-engineering, Electronics and Automation – MSTU MIREA, Honored Scientist of RF, Laureate of RF Government Award in Education, and twice in Science & Technology, M.V. Lomonosov Award in Science and Education.

E-mail: rector@mirea.ru

ANDREI V. SIDORIN

Candidate of Technical Sciences, Associate professor of Department of Materials and Specific Radio-electronics Products, Moscow State Institute of Radio-engineering, Electronics and Automation – MSTU MIREA; laureate of RF Government Award in Education.

E-mail: sidorin@ekb.ru

ALEXANDER V. SKRIPACHEV

Candidate of Technical Sciences, Director of Automotive and Mechanical Institute, Tolyatti State University.

E-mail: vev@tltsu.ru

ALEXANDER K. TOMILIN

Doctor of Physics &Mathematics, Professor in East Kazakhstan State Technical University n.a. D. Serikbayev, Director of QMS Department, Honorary Fellow of Education of Kazakhstan Republic.

E-mail: aktomilin@gmail.com

SERGEI O. SHAPOSHNIKOV

Candidate of Technical Sciences, Associate professor in Department of Management and Quality System, Executive director of Information Expertise Center in Engineering Education Development, Saint-Petersburg State Electrotechnical University "LETI".

E-mail: SOShaposhnikov@gmail.com

OLGA S. SHIKULA

Assistant of Quality Management System Department, Master student in Engineering and Technology "Electronics and Micro-electronics" National Research University of Electronic Technology MIET.

E-mail: oshik78@mail.ru

Summary

NATIONAL DOCTRINE DESIGN PRINCIPLES IN RUSSIAN ENGINEERING EDUCATION WITHIN NEW-TYPE INDUSTRIALIZATION: PROBLEMS, OBJECTIVES, CHALLENGES

Y.P. Pokholkov, B. L. Agranovich,
National Research Tomsk Polytechnic University

The authors analyze contemporary conditions of Russian engineering education and propose principles and strategies to improve Russian engineering education according to modern requirements.

SYSTEMS ENGINEERING AS AN ESSENTIAL ELEMENT OF MODERN ENGINEERING EDUCATION

G.V. Arkadov
All-Russian Research Institute for Nuclear Power Plant Batovrin Victor Konstantonovitch
V.K. Batovrin, A.S. Sigov
Moscow State Technical University for Radioengineering, Electronics and Automation

We discuss the need for education in systems engineering, the problems of organizing such education and requirements for educational programs in this area. It is shown that training in systems engineering is a key tool for shaping a new generation of engineers who are ready to create a competitive system for the global market.

DEVELOPING CREATIVITY TRAINING IN ENGINEERING EDUCATION

V.I. Livshitz
University of Ben-Gurion of Negev, Beer-Sheva, Israel

The article considers a complex problem of creativity training in engineering education. Creativity of engineers is based on the overcoming of "immaturity" and incompetence of graduates in accordance with the requirements of competence approach in engineering education.

CREATIVITY TRAINING IN ENGINEERING EDUCATION

S.A. Podlesny
Siberian Federal University

There are analyzed proposals suggested in V. I. Livshits's paper on the problem of creativity formation in the course of training the engineer. It is specified that it is necessary rather to optimally combine fundamental and professional training than to substitute fundamentalization of engineering education for professionalization.

REVIEW OF ACCREDITATION OF ENGINEERING EDUCATIONAL PROGRAMS IN LITHUANIA

S.O. Shaposhnikov
Saint-Petersburg State Electrotechnical University "LETI"

The paper presents review of the specific features of legislation documents and further implementation of external independent assessment of engineering educational programs in Lithuania.

THE ISSUE OF TRAINING AND QUALIFICATION OF RUSSIAN ENGINEERS

V.V. Eltsov, A.V. Skripachev
Togliatti State University, Institute of Mechanical Engineering

Only professional engineers can provide modernization of the national economy. These engineers should possess not only high professional skills but also the initiative, creative approach to decision making and high responsibility for the results of their engineering activity. In order to train such graduates the university programmes have not only to meet the requirements of the Federal State Educational Standards but also increase

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it significantly in the field of orientated development of the graduates' competences under conditions of systematic interaction with employers to implement training competence model for future engineers. The socio-professional accreditation of such an educational programme, which is carried out in accordance with worldwide criteria, gives a graduate an opportunity to be licensed as a Professional Engineer at National or European Engineer Certification Centers.

EDUCATION QUALITY ASSESSMENT IN HIGHER EDUCATION INSTITUTION

A.K.Tomilin
East Kazakhstan State Technical University named after D. Serikbayev

The article describes a conceptual model of the education quality assessment based on the principles of the international standards ISO. This systematic approach involves the professional formation of every instructor and evaluates his/her qualification. The experience of East Kazakhstan State Technical University named after D. Serikbayev is described.

EVALUATION OF EMPLOYABILITY (TECHNICAL UNIVERSITY GRADUATE EMPLOYMENT RATE)

M.V. Pokrovskaya, A.V. Sidorin
Moscow State Institute of Radio-engineering, Electronics and Automation

Higher institution efficiency is determined by employability and education quality of the institution itself, whereas efficiency criteria are based on the compliance of graduate competences to employers' requirements, as well as their labour market competitivity. Development strategy of this or that institution, as well as its policy, target and objectives in education, research and innovation significantly depends on future graduate employability and his or her professional competitivity. This fact highlights the definition of graduate employability as education quality assessment criterion and as an indicator of labour market demand. Besides, graduate employability is also an indicator of employer satisfaction and continuous improvement of graduate competences which, in its turn witnesses the attractiveness of this or that institution.

STATISTICAL QUALITY EVALUATION APPROACH OF EDUCATION PROGRAMS

M.V. Akulenok, N.M. Larionov, O.S. Shikula
National Research University of Electronic Technology

This article is devoted to the development of quality assessment techniques for educational programs involving the individual results of graduate learning outcomes. This statistical approach characterizing the quality of educational programs and denoting learning results as a system introduces not only an entropic indicator as quality indicator of educational program as a whole, but also as a level indicator of discrepancy in the system itself. The statistical approach was examined. The sources of the internal and external validity are shown.

INNOVATIVE DEVELOPMENT STRATEGY MANAGEMENT SYSTEM IN TECHNICAL UNIVERSITY

A.V. Sidorin
Moscow State Institute of Radio-engineering, Electronics and Automation

Innovative development strategy management system in technical university is the contemporary issue determined by the state policy in education and at the same time is one of the priorities in providing innovations in undergraduate education, development and implementation of integrated and innovative programs solving human resource and research problems in innovative economy development based on education, research and production activities. No matter

what type of university the successful implementation of innovative development strategy management system in technical university is determined by the efficiency of the innovative development strategy management system itself the model of which is described in the present paper.

TECHNOLOGY TRANSFER. COMPARATIVE ANALYSIS OF RUSSIAN, AMERICAN AND BRITISH UNIVERSITIES

E.O. Akchelov, S.L. Eremina
National Research Tomsk Polytechnic University

The article analyzes the technology transfer within Russian, American and British Universities showing the statistic significance in order to accept or reject hypothesis about opportunity to use USA and UK experience in Russian universities.

QUESTIONNAIRE AS A PROSPECTIVE INSTRUMENT OF STUDENT INVOLVEMENT IN RESEARCH ACTIVITIES

N.N. Kairova, B.B. Moises, L.M. Zol'nikova
National Research Tomsk Polytechnic University

The article discusses the influence of student research activities on higher professional education development. The perspective implementation of questionnaire as instrument of student involvement in research activities is presented.

INTERNATIONAL COLLABORATION IN PROFESSIONAL EDUCATION

E.L. Rudneva, M.P. Paljanovв
Kuzbass Regional Institute of Professional Education Development

The article describes the theoretical and practical issues in international collaboration to improve graduate competitivity of Russian higher professional education institutions based on the implementation adapted foreign experience.

CONTEMPORARY CONDITIONS IN ENGINEERING EDUCATION. OVERVIEW

E.A. Arkhangelskaya, S.G. Antsupova
North-Eastern Federal University

The article examines the problems in regional higher engineering education system and their solutions.

ENGINEERING TRAINING FOR KNOWLEDGE-BASED AND HIGH-TECH INDUSTRIES

O.A. Gorlenko, V.V. Miroshnikov
Bryansk State Technical University

The engineers training issues for high-tech and knowledge-based industries are considered in the article. The authors propose a specialist competency model, design pattern for professional standards, graduate competence model, compliance criteria of graduate competences to professional standard requirements.

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 ENAEE (European Network for Accreditation of Engineering Education). AEER was entitled to assigning the international certification label (EUR-ACE 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 (30.06.2012) 78 EUR-ACE labels were awarded to 159 accredited education programs from 30 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 01.01.2012)

	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
	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
	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

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
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
	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	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
	Moscow Institute of Electronic Technology (Technical University)				
1.	210100	FCD	Electronics and Microelectronics	AEER	2003-2008
2.	230100	FCD	Computer Science	AEER	2003-2008
	Moscow Power Engineering Institute (Technical University)				
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 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	Metallurgy (Physical Metallurgy of Non-Ferrous, Rare-Earth and Precious Metals)	AEER EUR-ACE®	2011-2016

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
6.	150400	FCD	Metallurgy (Functional Materials and Coatings)	AEER EUR-ACE®	2011-2016
7.	150400	FCD	Metallurgy (Metal Forming)	AEER EUR-ACE®	2011-2016
	Novosibirsk State Technical University				
1.	150501	INT	Materials Science in Mechanical Engineering	AEER EUR-ACE®	2012-2017
	Samara State Aerospace University				
1.	160301	INT	Aircraft Engines and Power Plants	AEER EUR-ACE®	2008-2013
2.	160802	INT	Spasecraft and Rocket Boosters	AEER 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
	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
	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	Mechanical engineering technology	AEER EUR-ACE®	2009-2014
	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

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
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
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 Navigation Systems	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

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
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
	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
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	Land cadastre	AEER EUR-ACE®	2010-2015
	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

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
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

List of Accredited Programs, Republic of Kazakhstan
(as of 01.06.2011)

	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	AEER EUR-ACE®	2011-2016
6.	6N0901	SCD	Organization of Transportation, Traffic and Operation	AEER EUR-ACE®	2011-2016
	Инновационный Евразийский Университет (г. Павлодар, Республика Казахстан)				
1.	050701	FCD	Biotechnology	AEER EUR-ACE®	2010-2015
2.	050718	FCD	Electrical Power Engineering	AEER EUR-ACE®	2010-2015

	Program Code	Qualification	Program Name	Certificate	Accreditation Period
	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

ARTICLE SUBMISSION GUIDELINES

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Authors are requested to submit the text in electronic form. It is important that the file is completed using Microsoft Word software and saved in the native format of the wordprocessor .doc extension. For the file name, please, use author's family name (for example, Petrov.doc)

Page Setup:

Paper size: A4 Margins: top & bottom – 30 mm; left – 22 mm, right – 28 mm

Text Format:

Number all pages; place the number in the bottom right hand corner of the page. Use 1.3 – line space within the paper.

Font size:

Times New Roman, 14 pt.

Paper Length:

6-10 pages, including all tables, figures and notes.

Article structure:

title, Last name Name of authors, organization, e-mail address, abstract, key words, main text, references, epigraph can be added.

Abstract:

A concise and factual abstract is required (of no more than 40-50 words). The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented in Russian, before the main text and after the title of the article.

Key words:

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The list of Literature Cited should be included after the final section of the main article body. References should be arranged in the same order as they appear in the article. All references listed must be cited in the text. State Standard style must be followed for the references. For citing please indicate the reference number and page numbers in brackets (for example, [3, p. 14-16]).

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esponsible for the release:
S.V. Rozhkova
Editorial office address:
7 building, 78, Vernadskogo Prospect,
Moscow, 119454, RUSSIA

Telephone/Fax: +7 (499) 7395928,
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