JOURNAL ASSOCIATION FOR ENGINEERING EDUCATION OF RUSSIA

ENGINEERING EDUCATION

ISSN-1810-2883

10'2012

THEME OF NUMBER: APPROACHES TO THE DEVELOPMENT OF ENGINEERING EDUCATION DOCTRINE IN THE CONTEXT OF NEW INDUSTRIALIZATION

ENGINEERING EDUCATION
10'2012

Editorial board

DEAR READERS,

Russian engineering education has a glorious more than 300 years history and rich traditions. Since the establishment of the School of Mathematical and Navigational Sciences by Peter the Great, traditions of Russian engineering education have developed and strengthened. These traditions are based not only on the mentality of the Russian people (curiosity, quick wit, commitment to results, desire and ability to bring the efforts to a successful conclusion), but also on the governmental support of the engineering education system. There is a great variety of evidence since Peter the Great, who sent Russian youth to study shipbuilding in Europe and opened the above mentioned school, in fact the first engineering school in Russia.

Another example is the first engineering school founded by Catherine II in 1773 in St. Petersburg (Mining Institute). It is worth noting that four years later she issued a decree to establish the Mining Museum in this university. Russian industrial and mining enterprises were bound to supply the museum with the latest technological developments. This chain could be continued by establishing of the Moscow Higher Technical School named after N.E. Bauman, that later became Moscow State Technical University n.a. N.E. Bauman (MSTU) - Russian Engineering University of educational excellence always supported by any government. We could also talk about a legendary foundation of Tomsk Technological Institute of practical engineers in 1896, when count S.Yu. Witte, being at that time the Minister of finance of Russia, made a historical record in his diary, “Today, March 5, 1896, I struck out provision for armadillo and transferred these funds to establish the Tomsk Technological Institute.“ the race of armadillos, built at the time, finished long time ago and the Tomsk Technological Institute - the first technical higher educational institution in the Asian part of Russia, and now the National Research Tomsk Polytechnic University, has been living, developing and benefiting motherland for more than 110 years.

Impact of engineering education on the country’s economic development, the level of technical and technological culture among the population, ensuring its economic and technological security is crucial. In support of this thesis there are vivid evidence only in the last 100-150 years. Development of domestic aviation, exploration and development of mineral resources (especially in Siberia), electric power and hydro engineering, nuclear and chemical technologies, nuclear power engineering, space exploration, etc. These achievements became real thanks to gifted, talented people, graduates of local technical higher educational institutions: N.E. Zhukovsky, S.P. Korolev, N.A. Dolezhal, M.K. Korovin, I.V. Kurchatov, M.L. Mil, A.P. Tupolev, N.I. Kamov, V.N. Schukin, N.V Nikitin and millions of “ordinary” engineers without whom it is impossible to imagine any design, production or exploitation the variety of engineering technics and technology, equipment, that concentrated brilliant engineering solutions.

Unfortunately, in modern Russian history there is a trend pointing out how professional community and authorities break with the glorious traditions of the Russian engineering education. The reasons for this are explained by inadequate response to the challenges sent by environment to the government and academic community.

Russian engineering education in recent years has faced a number of global and national challenges, the most severe are the following:

- transition on a multilevel system of education in accordance with the basic principles of the Bologna Declaration;
- Russian WTO Accession, competition in the global engineering market;
- sharp decline of the image and status of the engineering;
- lack of common requirements for the qualification of specialists in the field of engineering and technology, professional standards taking into account the transition to two-tiered training system;
- market-based employment relationship;
- the contradiction between the previous system of engineers

training and new requirements from employers;

- getting out of date facilities and aging human resources of universities;
- a small number of enterprises with modern equipment to provide good quality of practice training for future engineers and university professors.

Failure to adequately and promptly respond to these challenges has resulted in critical state of engineering education in Russia. To some extent, this failure has also become a reason of crisis in engineering - products resulting from engineering activities: projects, technologies, facilities, machinery, instruments, equipment, operation and maintenance.

One of the causes of the crisis in engineering education and engineering is the contradiction between the quality of engineers' training and employers' requirements.

Employers look for such professionals who:

- are able to think independently, systematically and efficiently solve production problems using competencies developed in university;
- know business processes and features of the Russian business environment
- know the laws and methods of creative thinking to find solutions of engineering problems;
- know methods of nonlinear physics and nonlinear dynamics of complex systems (synergy), fractal concepts;
- are able to use the elements of the Applied Systems Analysis;
- are able to use high-performance integrated computer network design tools (CALS-technologies);
- are focused on the professional development and career growth;
- have business communication and negotiation skills;
- are able to present themselves and the results of their work in a professional environment;
- have teamworking skills;
- have high foreign language proficiency level.

As a rule, the content of engineering curricula and educational technologies used today, do not allow to develop such qualities while training future specialists.

Universities organize the training process in such a way that the graduates primarily should have knowledge in the disciplines studied at university. In this case, each teacher believes that the more hours he would have to teach their discipline, the better he will prepare a specialist. As a consequence, the criteria for assessing the quality of training of future engineers in higher educational institutions are shifted to the assessment of their knowledge.

Finding answers to these challenges requires a meaningful and systematic approach to analyze current situation and to choose appropriate responses to these challenges. One of the main tools for this could be the development of a fundamental document the "National Doctrine of Engineering Education of Russia". Its preparation and implementation should assure strengthening and development of the best traditions of Russian engineering education as the basis for successful economic and cultural development of the nation.

In general terms the doctrine is "a collection of officially accepted views on any issue and the nature of its solution" *.

In any case, the doctrine is an important strategic document based on a specific philosophy that helps to state the objective and describes how to achieve it in a certain field of activity for a long period of time. The importance of developing the "National Doctrine of Engineering Education of Russia" at the present stage of economic development is obvious.

The "National Doctrine of Engineering Education of Russia" based on objective and adequate assessment of the situation prevailing in the field of engineering education in Russia and in the world, should include the definition of the strategic goal of national engineering education and its role in the development of the Russian economy, the tools and means of improving the methodology, key principles of the

Doctrine. Of course, the objectives of the development of engineering education, applied methodology, tools and techniques may be different. Their selection and implementation of their principles should be carefully analyzed and discussed by specialists and society at large.

On December, 4-6, 2012 All-Russian Scientific and Practical Conference "Approaches to Development of the National Doctrine of Engineering Education in the New Industrialization" will be held in Tomsk.

The Conference is organized by the Association for Engineering Education of Russia, the Association of Technical Universities of Russia, the Association of Innovative Regions of Russia, National Research Tomsk Polytechnic University, Administration of Tomsk Oblast, Administration of Novosibirsk Oblast, Foundation for Assistance to Small Innovative Enterprises in Science and Technology. The Conference will be held with the support of the State Duma Committee on Education, Council of the Federation Committee on Science, Education, Culture and Information Policy, Bauman Moscow State Technical University, RF Chamber of Commerce and Industry.

The publication of this special issue of the journal "Engineering Education" is dictated by the need to give an opportunity for representatives of business, science and engineering education community in Russia to get acquainted with the opinion of the country's leading experts on how to develop the Russian engineering education.

The first part of the journal contains articles about the experience of the organization of national higher engineering education and the problems we face in this field today. The second part of the journal presents articles of the authors who share their ideas on how to improve engineering education in Russia and discuss approaches to the development of the National Doctrine of Engineering Education.

The Editorial Board hopes that the publication of this issue will initiate more discussions on how to develop and improve engineering education. And the forthcoming conference will become a good platform for further discussion and recommendations on the development of the "National Doctrine of Engineering Education of Russia." Implementation of the National Doctrine will ensure solution of human resources problems of the Russian economy on the basis of the new industrialization.

Sincerely,

Editor-in-Chief,

Prof. Yury Pokholkov

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* *Big encyclopedic dictionary*

Contents

UDC 378.091
(Universal Decimal Classification)

The Bauman MSTU: experience, traditions and innovations in engineering and scientific staff training

The Bauman Moscow state technical university (The Bauman MSTU)
A. Alexandrov

The article deals with the totality of problems concerning engineering education and universities' activity at the present stage of education system reform. It analyzes topical problems and shows possible ways of their solving in relation to historic experience and training traditions of The Bauman MSTU. In fact, it gives the characteristics of a contemporary technical university, the problems of formation of its unique scientific and educational environment within which engineering elite can be trained, using the scientific potential effectively and providing a real universities' contribution into Russian economy modernization.

Key words: *problems of engineering education, history and traditions of the Bauman MSTU.*

A.A. Alexandrov

Contemporary technical university, staff training, research work, engineering education plays a crucial role in achieving sustainable socio-economic development, when revival efforts for Russian economy are being taken within the process of economic transition to an innovative socially-oriented model.

However, there is a decrease of prestige, quality and relevance of engineering education as well as most engineering research activities. This is recognized by the state establishment . They place emphasis on the fact that "we are facing a big threat - the threat of devaluation of higher education in general and engineering education in in particular. Unfortunately, within the nineties the value of higher education notably decreased"(D.A. Medvedev) [1].

Obviously, the engineering education needs to be reformed. However, we should not forget that the national education system formed through the centuries is unique. So, higher professional education of Russia is competitive in many areas. Its main advantages include fundamental, systematic, world-view panoramic characteristics and practical orientation.

Most problems of higher education are already defined and obvious. They are constantly and actively discussed in the academic community. In general, these are the following issues: how to optimize the network of educational institutions, organizational, managerial and financial tools of universities. The issues of lifelong learning and the quality of training in-demand specialists at various levels, the structure and content of higher education, the introduction of new educational technologies are of fundamental importance. Acute problems of research activities are as following: insufficient effectiveness of innovation, a gap between "theory and practice", when many scientific and theoretical innovations are not in demand and do not become commercial, poor research and laboratory facilities, undeveloped infrastructure of universities, etc.

As is known, the world's main trend of modern society development is the transition from the paradigm of resource and industrial economy to the paradigm of the "new economy", also called "knowledge economy", "knowledge based economy" or innovative economy.

Priority is given to the development of high technologies, research, establishing world-class technical universities, making engineering profession and engineering work the most prestigious and highly paid ones.

The history of Moscow State Technical University named after N.E. Bauman is a reflection of engineering education development stages in Russia, and specific examples of its work in fact are time-tested, real and possible solutions of challenges in engineering training, development of higher technical education, advanced training educational practice.

MSTU is recognized for a wealth of experience and the quality of engineers' training, results of research and innovative activities, practice and close cooperation of higher education institutions with industry leaders and research institutions of high-tech complex, development and analytical research on professional education. All of these helps determine objectives, criteria and performance targets for engineering universities of the country.

Historically and currently MSTU develops and positions itself as a high school, giving education and conducting research in a wide range of areas relating to the cutting-edge, critical areas of science and technology.

Our university is one of the oldest engineering schools in Russia, its history dates back to July 1, 1830 when it was founded by Emperor Nicholas I as Vocational School for training "craftsmen in theoretical knowledge, serving for modernization of crafts and factory works". In 1868, it converted to the Emperor's Moscow Technical School with the "Statute on the Vocational School".

The system of training of future engineers gained recognition all over the world. The so-called "Russian method of training engineers" became widely known, especially after its successful demonstration at international exhibition in Vienna (1873), where it was awarded the Big Golden Medal [2].

MSTU was the first among technical higher educational institutions that received the status of technical university in 1989.

Today Moscow State Technical University named after N.E. Bauman is the National Research University of Engineering and Technology. The category "national research university" is established by the Government of the Russian Federation according to the resolution dated November, 2, 2009.

The main principle of training specialists in Bauman Moscow State Technical University is "education through science", based on the best traditions of the Russian school of engineering, in-depth knowledge of basic sciences, vocational and practical training.

Special focus on the fundamental knowledge allowed creating a unique scientific and methodological school, and becoming a real elite technical university. Well-known scientists, who conducted here their research, became founders of scientific schools that gained recognition all over the world. Notable public figures, business leaders and heads of scientific organizations, designers and leading experts in the field of engineering, rocket and space technology, electronics and instrumentation, automation, defense industry worked and studied in the university.

The quality of training at the university is determined by the educational standards and programs. MSTU was granted the right to work according to its own sets of educational standards and requirements. Currently, the university has developed new, mostly unique and competitive programs that meet modern trends of innovative economic development of the country. A large variety of programs, opportunities to diversify learning trajectories completion dates create good preconditions to meet the broad queries in relation to a variety of career guidance and level of training of graduates of the university.

Knowledge in the field of engineering and technology tends to get out of date quickly, and the universalism (flexibility) of modern specialist is not based on the volume of acquired knowledge and skills. Knowledge of an engineer is based on his background in natural sciences, mathematics and philosophical foundations, scope of interdisciplinary system-integrative knowledge about nature, society, thinking, as well as a high level of general and specific knowledge required to act successfully when solving a problem.

To meet the challenges of modernization of the Russian economy and to develop a national innovation system it is requited to have a pool of highly qualified competitive professionals of different levels (bachelors, masters, engineers) who are ready for creative and proactive activities and are able to combine comprehensive research, design and entrepreneurship. Regarding the claims of employers to graduates of technical universities: the point is that in modern industry (design bureau, research companies) there is requirement for design and development engineers - highly qualified specialists should be able to create new technologies and techniques, and in particular enterprises there is requirement for service engineers.

All educational programs of the university are systematically provided with the necessary methodological, financial and human resources: textbooks, computer labs and modern laboratories, appropriate organization of training process and its control, mandatory involvement of students in research work, all kinds of practice training at leading enterprises and research companies in the field of high technology.

MSTU is intensely focused on creating unique scientific and educational environment aimed at the fulfillment of tasks of the research university and the ability to form a scientific and engineering elite.

Engineering Education and Research Center "New Materials, Composites and Nanotechnology" provides the opportunity engineering activities based on "closed-loop" principle: from development of new materials and technologies and their processing to design and manufacture of products. The Center combines scientific and engineering knowledge of Bauman Moscow State Technical University with its experience in applied research and production capabilities of federal state unitary enterprise "All-Russian scientific research institute of aviation materials".

In April 2012, "Photonic and IR-technic Scientific and Educational Center" was opened in MSTU. The opening ceremony was attended by the President of Russia Dmitry Medvedev, representatives of the Russian Academy of Sciences and and leading research institutes, famous Russian and U.S. scientists. The Center is aimed at creating a Russian world-class scientific and engineering school in the field of optoelectronics. Scientific management of the center is carried out by outstanding scientists in the field of research of semiconductor structures - Victor Ryzhyi, professor of Aizu university (Japan) and Vladislav Pustovoyt, member of the Russian Academy of Sciences, Head of Department of Moscow State Technical University n.a. N.E. Bauman.

The structure of the university is also improved and modernized. Basic structural unit of the University is a Research-Educational Complex (REC). It consists of faculties and research institutions, representing a combined research and educational center in the direction of its activities. At first, this allows to integrate the educational process and scientific activity, and second, to ensure the interdisciplinary nature of the research, the need for which arises almost in all modern research and applied scientific papers that are usually integrated.

Branches of departments founded at enterprises and research companies ensure close relationship with academia and industry. In the structure of the REC there are also industry or corporate departments, based in the leading companies in the space and defense sectors, such as JSC "Concern "Almaz-Antey", S.P. Korolev rocket and space corporation "ENERGIA", "Military and industrial corporation JSC "MIC "Mashinostroyenia" (Reutov), JSC"Krasnogorsky Zavod", JSC "Moscow factory of electromechanical equipment" and Center for operation of space ground-based infrastructure (TsENKI). These firms provide all conditions (classrooms, science labs) necessary for the full-time training process of students and their research work [3].

One of the main tasks of MSTU is not only to maintain and not lose the leadership position, but also to reach a new level in all areas. To this end, the Development Program of MSTU as a National Research University of Engineering and Technology has been developed and implemented.

The effectiveness of the use of scientific and intellectual potential of the university, development and production of innovative products is a measure of its scientific and technical innovation. Close cooperation of university research and industry is most evident in the research and development projects on the orders of the enterprises. Over the past few years important for the national economy results were obtained on the basis of the research conducted by the scientists of MSTU. For example: development and implementation of integrated systems for evaluating the condition and reliability of complex technical systems (such as nuclear power plants, facilities at the spaceport, large gas pipeline system etc.), their residual life analysis. A set of robotic systems is being developed: mobile robots designed to work in extreme conditions (including anti-terrorism efforts and for the purpose of remedying the consequences of man-made disasters and emergencies), the unique deep-sea vehicles for special underwater operations. Medical and biomedical equipment, equipment for the use of molecular genetic methods in biotechnology and bioengineering were developed. Radio-electronic and opto-electronic devices and next generation devices, often unmatched in performance were developed and implemented. Research in the field of nanotechnology engineering is being conducted. All these achievements are the result of research conducted by world-known scientific schools of the university.

Science and research at university always played a particularly significant role as an essential part of high quality education.

These are the main objectives of the university in its research activities:

- improving the quality of training through the active use of research in the learning process and the involvement of students in their implementation;
- foundation and development of teaching schools and training of scientific and pedagogical personnel;
- advanced development of basic and applied research as the basis for the creation and development of new technologies;
- exploration, development and implementation of innovative projects to facilitate formation of the market of high technologies and intellectual property;
- development of international scientific and technological cooperation, active foreign-economic activity in order to consolidate and expand the position of the university research team in the world scientific community;
- protection of intellectual property and copyright of researchers and developers, enabling output of research teams in the world market of high-technology products.

One of the main goals of preservation and development of scientific and pedagogical potential is to create conditions to attract talented young people and keep them working in science, engineering and education.

Nowadays universities training specialist for high-tech sector and the defense industry face with admission problems for the professions that used to be prestigious. A significant part of applicants to innovative engineering educational programs have insufficient knowledge and are not prepared for learning, many students do not connect their future careers with the direction of their educational programs.

MSTU implements a unique method of support and development of scientific work with young people and students, provides conditions for the full development and nurturing creative person's individuality, gradual formation of professional competence and lifelong learning. For many years unique and the most ambitious Russian scientific and social program "Step into the Future" has been successfully implemented at MSTU. Its main purpose is to create conditions for school students to graduate successfully from secondary education, prepare for university and adapt to post-secondary education. The program is aimed at screening and attracting talented, well prepared and professionally oriented youth. Graduates from Bauman Moscow State Technical University do not have employment problems, and their diplomas do not need to be confirmed abroad. Therefore Bauman graduates easily find work in any country, they are very popular in Germany - a country with a great technical education.

Doctoral and post-graduate training are the main forms of training research staff. Today, such concept as philosophy of scientific training, selection and orientation of the best students for research and teaching acquires a special meaning,. There is no secret that according to opinion polls among the reasons why many graduates are not willing to continue their career as a scientist or university teacher are as following: low salary, lack of modern facilities for scientific research; excessive bureaucratization of scientific work organization , low prestige of scientific and pedagogical work. (Modern engineers and scientists face the challenge of realizing their full research potential and solve their social and economic problems, significant difficulties in conducting research, etc.).

There are positive trends in this work. More than 300 young, talented teachers who connect their lives with Bauman Moscow State Technical University are highly motivated while working in MSTU. They remember and continue traditions of scientific and pedagogical schools.

It must be noted that on the basis of scientific schools of Moscow State Technical University nearly 30 higher educational institutions, military academies, industrial research institutes were founded. All of them got great initial impulse from MSTU at the very beginning that allowed them promptly to become leading research and educational centers of the country.

We often look back and repeat the words about past successes of Russian education.

The task of preparing a new corps of engineers is not new, conforming to the new stage of the country development.

We should just look back in our history. V.I. Grinevetsky, the first rector of the Moscow Higher Technical School in the report of the Polytechnic Society Meeting on January 17, 1915 "On the reform of engineering education", when analyzing the reasons for the technological development lag of Russia and listing the most topical problems of that time and prospects of the development of engineering education, made proposals how to meet this challenge. He was convinced that "... the development of engineering education has to develop in two directions. On the one hand specialization of teaching staff should constantly increase, on the other hand, interaction of various disciplines should become closer ".

Below you can find some extracts from the report [4].

"What could be the objectives of the necessary evolution of our engineering education? .We have to talk about a solid mastery of general scientific subjects, about need to strengthen technical training, develop it in new directions required by the evolution of technological tasks, the overall vitality of scientific training to make more use of appropriate methods and knowledge to conduct training in the economic area ...

One of the solutions is, of course, specialization of technical education, which certainly requires our large industry. Under such conditions it is possible to get a specialist who is ready (well prepared theoretically and practically) for the work he had learned independently in at least one specific area and after that he will be able to easily specialize in new directions. It is hard to get experts from those who have smattering of knowledge, and we constantly make sure of this fact on practice.

Link of professors with engineering practice is weak and random. Only close enough contact with real life allows revealing new tendencies and implementing new technical material. ..We have to accuse our curriculum of lack of flexibility...

The current situation demands from schools at least large enough independency, and sufficient level of responsibility. And it is hard to require all these from those institutions, which are tied to the last detail ".

It cannot be denied that this exact assessment and objectives formulated to improve engineering education for development of the Russian economy at the time are quite topical and you even actual.

Of course, the current approaches to the solution of the above stated problems are very different. However, they are fully based on the tradition and modern practice of engineering education.

New challenges require a new generation of university professors. There are specified requirements to their personality, competence, professional and pedagogical culture, scientific knowledge. In fact it means restructuring of research and teaching staff. We have two major problems with research and teaching staff : age (high average age) and professional competence. It is obvious that we need to include teachers in research and innovation, and this should become one of priorities. Development of new courses and disciplines, methodologies and learning technologies requires new motivation, knowledge and skills. In this regard, there is a system that provides a systematic professional development of our teachers, exchange of good practice in the field of methodological work, its improvement, development of specific methods of engineering education, study of international experience.

The tasks and objectives to establish world-class universities that should be completed by the leading universities of Russia, including MSTU, are complex and comprehensive. Such university is characterized by a set of unique qualities, including high prestige and international reputation in the field of training, research, creating of innovative ideas, providing high quality and favorable conditions for training and research (modern buildings and equipment), etc. It takes time to achieve these characteristics and the following measures should be taken: qualitative changes in the university system, its structure, management system and financial security.

Academic community with a certain anxiety looks forward to governmental steps in reorganizing of higher education institutions. There are objective reasons for reorganization of universities that include: demographic decline, structural changes in the economy. The ultimate goal of universities merging should be to improve the quality of learning outcomes and graduates through the integration of financial, material, technical and intellectual resources. We hope that the inevitable reorganization of the "ineffective" schools will be carried out carefully and cautiously, and at the same time will define the risks and negative effects. Just merging and consolidation of educational institutions, the artificial restriction of state support of universities according to their priority, may cause damage to education system, lead to irretrievable loss of the unique teaching staff and scientific schools. There should be well-defined criteria for evaluation of higher education institutions on various activities, principles of reorganization of universities, public discussion of these issues by all stakeholders.

The concept of development of Russian engineering education is almost determined, but it requires continuous improvement, adaptation to the new socio-economic conditions and to the needs of society. This problem is topical for all universities.

All the above mentioned facts do not mean that there are not any problems at the University, its activities fully meet current requirements. We associate development of Moscow State Technical University n.a. N.E. Bauman with that margin of safety and, above all, with the historical experience, traditions and intellectual potential, that help us to hold one of the leading positions among Russian technical universities.

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UDC 378.016
(Universal Decimal Classification)

Problem situations in Engineering education

Siberian State Academy of Geodesy
A.P. Karpik

The article suggests a competence and qualification approach to formation of engineering training innovative model. The approach takes into account a regional component and is based on integration of cluster interaction of continuing education participants.

Key words: *innovative engineering training, competence and qualification approach, cluster, human recourse, real economy.*

A.P. Karpik

In the post-industrial age society has accumulated a scope of basic and applied knowledge, a huge information resource has been developed. Today the main objective is to create new competitive products and new markets by applying knowledge management prin-ciples. Innovation in technology is being formed on an interdisciplinary basis as a result of the transfer of knowledge from one area to another. Distribution and combination of basic and applied knowledge, and moreover their use in an "unexpected way" for all practical purposes becomes the main purpose for engineer in his innovative activities.

In this context, a new approach in engineering education has been developed. Innovative engineering education is the process and the result of purposeful formation and development of specific knowledge, skills and methodological culture, as well as com-plex training of specialists in the field of engineering and technology for innovative engineer-ing activities through appropriate content, tools and technologies [1].

Nowadays a lot of experts hope that Russian high quality engineering education could be saved if two main problems were solved. First of all, we need to strengthen cooperation between technical universities and real economy, provide bilateral contacts of universities with industry, employers and market. Development and introduction of federal state educational standards (as well as educational programs) for new generation tends is one of priorities.

It is undoubtedly true, but, in our opinion, it is necessary to start with the development of a modern engineer model l on the basis of competence and qualification approach (Fig. 1), and key competencies definition of future specialists for different sectors of economy (Fig. 2).

There is no coincidence that resolution of the 15th Congress of the Russian Union of Industrialists and Entrepreneurs (RSPP, Moscow, 18.04.2006) points out the need of further development of the positive results in the reform of vocational education, development of partnership between government and business in this area. The Russian Union of Industrialists and Entrepreneurs took the initiative to develop professional standards. Though there are not any professional standards, universities need to train according to the new federal state educational standards.

Education process in accordance with the competency-based learning

Fig. 1. Mechanism to develop a modern engineer model

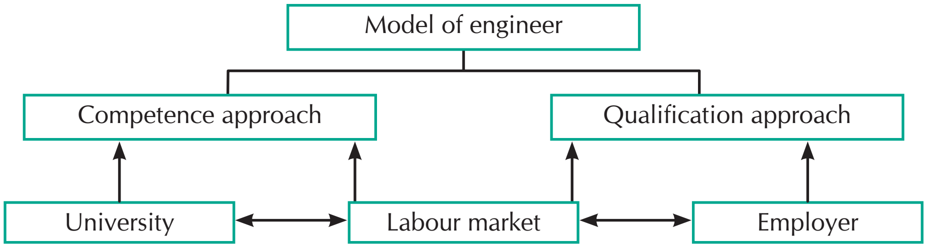
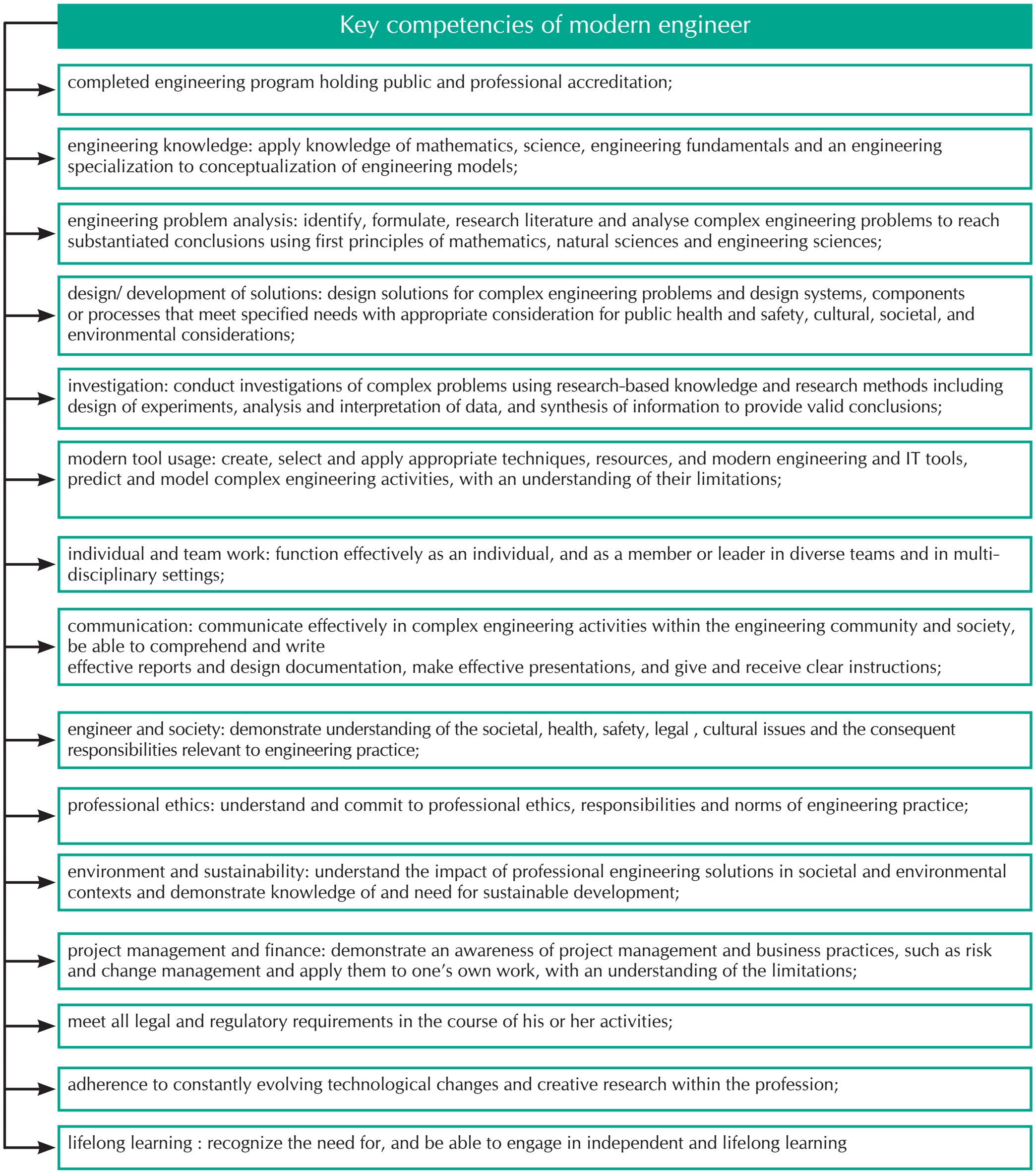


Fig. 2. Key competencies of a modern engineer



model will elimi-nate such shortcoming in the training of engineers as "knows everything, but cannot do any-thing". It will permit to implement a problem-based approach with the use of IT-technologies. This approach allows students to focus on the analysis and solution of real spe-cific problems.

Engineering education should be aligned to the needs of specific region and its socio-economic development. Development of the regional economy refers to the search of sources and directions of effectiveness based on the growth of material well-being of citizens and quality of their lives. The methodology of the social concept is based on improving the quality of life and ensuring the proportions of regional industries, which contribute to achieving the strategic goals of sustainable development of the region. Therefore, the modernization of the economy of the region, obviously, should be based on human resources and cannot be im-plemented without modernization of engineering education as an important condition for quality training of human resources.

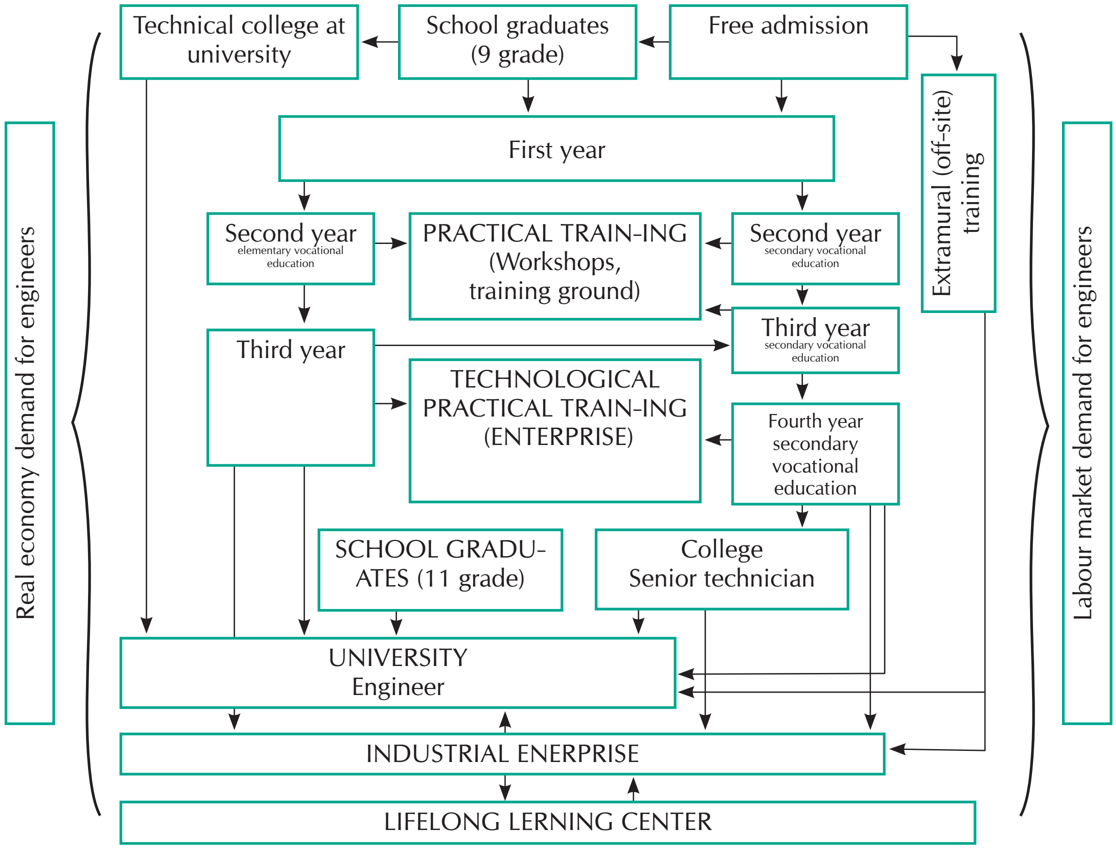
Modernization of higher engineering education in Russia, as well as many other national socio-economic objectives should initially be solved on the regional level. Thus, the main goal of higher education institutions is to train qualified engineering staff required by real economy of particular region.

Due to the fact that at the present time industry requirements for employees are con-stantly changing lifelong learning becomes the norm. And the ability to acquire new knowledge and skills is considered as the most important characteristic of the labor force.

Combination of region's need in engineering staff and the ability of human resources to train permanently allows to create a cluster of engineering education, embracing higher edu-cation institution, vocational education institution, technical high school at university, school, faculty of advanced training, sector of the economy (Fig . 3).

Development of regional engineering education cluster will permit to implement the strategy of a "double loop" in preparation of competitive engineering staff. The modernization of engineering education should be completed according to the principle "first think what would happen, and then do". But it does not happen in reality. Under these conditions, universities should have a certain extent of independence and mobility, whereas industrial enterprises should be given relevant operational rights for cooperation with universities as well as governmental support without bureaucratic delays.

Fig. 3. Model of engineering education cluster



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UDC 378.147
(Universal Decimal Classification)

Enhancing engineering education in the post-crisis period of economical development in Russia

St. Petersburg State Electrotechnical University "LETI"
V.M. Kutuzov, N.V. Lysenko, S.O. Shaposhnikov

V.M. Kutuzov

N.V. Lysenko

S.O. Shaposhnikov

In the developing economy of knowledge, the task of establishing and strengthening partnership with industry and the labor market as whole assumes the top priority. It needs developing a network of organizations interested in mutually beneficial collaboration in the area of training highly qualified engineers, improving the technical facilities of the academic process, conducting joint research, upgrading manufacturing facilities, etc. To make such collaboration a success, it is important to realize how to establish the university-industry partnership based on mutual interests and benefits. The article presents the experience of St. Petersburg State Electrotechnical University "LETI" in launching and running a University-Industrial Enterprises Strategic Partnership Program aimed at enhancing engineering education at the university.

Key words: *Multi-Level Engineering Education, Strategic Partnership, Industrial Enterprises, Centers of Excellence, Centers for Prototyping.*

Tendency to a steady growth in industrial production, research and development has revealed lack of highly qualified specialists who are aware of modern technology, able to implement competitive equipment and develop technologies in innovative professional activity within market economy. Today lack of qualified staff is a major obstacle for innovative development of those priority sectors of the economy, which have been supported by large investments in the recent years. .

The main contradiction of Russian higher engineering education today is the mismatch of professional competencies acquired by graduates of technical universities within the learning process with the increasing demands of high-tech enterprises, design and research organizations. As a result, in spite of quite large and often excessive amount of graduates from engineering educational programs business demand for high-quality professionals is not satisfied. The main challenge that higher engineering education faces at the moment and not only in Russia is a strategically important need for modernization of content and technology of education in the field of engineering and technology on the basis of cooperation and integration of human resources, scientific, technological and corporate capabilities of technical universities, research organizations and business. First, predictive analysis should become an integral part of modern engineering education in order to foresee fast-changing technologies of specialty profile. Taking into account that for modern industry a term ' leading-edge technology' became quite common and means fundamentally new technologies that ensure leading positions in the global market, modern engineering education should be far in advance of leading-edge technologies. Second, modern engineering education should be interactive and allow students and teachers within the training process to get professional competence to conduct independent research, to acquire and apply new knowledge, including its commercialization. Third, modern engineering education should be open and based on the principles of networking involving all stakeholders in the educational process. This will allow students and university teachers to acquire professional competence in world-class centers of excellence.

Multi-Level Engineering Education

The main problem that the developers of new state educational standards of higher professional education faced with the concerned bachelor programs. After obtaining bachelor degree graduates should be able to start work in the field of engineering and technology, this requires from the educational program to be practice-oriented (now called "applied" bachelor program). At the same time, those graduates from bachelor program who wish to continue their education at master level should get fundamental training: understanding of the natural science (physics, mathematics, chemistry) and professional specialist knowledge (in the chosen field of study).

Multi-level training system provides real flexibility in adapting the content of educational programs and allows students to select individual training profile. Implementing of this approach requires modernization of the educational process infrastructure. Improving efforts should be aimed at providing every student easy access to modern knowledge bases, technologies, advances in science and technology. In this case the most important role plays early career orientation of students (within the first year), which is carried out with the assistance of employers - strategic partners of the university. By the way, this approach is consistent with CDIO ideas in reforming engineering training, that was recently approved by a number of world leading universities [1].

According to the experience of our university the features and benefits of tiered engineering training are as following:

1. Competitive selection for the second level motivates students to be more active at the first level (good progress in studies, participation in research projects and university competitions, choice of employer, etc.). It allows to select most talented, creative and motivated graduates for master level programs.
2. Ability to work on the second level with the selected graduates makes training of elite professionals more efficient.
3. Increased elective component of professional training:
   - allows to undertake real targeted training " tailor made training";
   - motivates industry - strategic partners to develop and deliver targeted programs together.
4. Flexibility in the implementation of new profiles in bachelor's and master's educational programs introduced by the Academic Council of the university (unlike the traditional system of "engineering" programs with regulated list of professions).
5. Possibility of training specialists at different levels, competent in certain types of professional activities and tasks in accordance with professional standards.
6. Attractiveness of tiered training for foreign students. Programs can be easily harmonized with similar programs in the foreign higher education institutions.
7. Formation a real basis for academic mobility of students and teachers.

Saint-Petersburg Electrotechnical University "LETI" has adopted tiered engineering training system. Within the first two years students acquire engineering fundamentals "being trained in consistent (harmonized) direction, and then they could choose profile of their bachelor program. This choice is

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made by students after visiting enterprises - strategic partners of the university in order to get the idea of their possible future professional activities. After studying at bachelor level most qualified and competitive graduates can continue their studies and get a Master's degree in two years. Curriculum of master educational program is developed jointly with employers and meets the current requirements of the labour market and the latest developments in a particular field of engineering and technology. It should be noted that master degree studies is the priority of educational activities of ETU. Admission to state-funded places at master's degree programs is not less than 60% of the admission to the first year of bachelor's degree programs.

Involvement of strategic partners in the implementation of practice-based learning. Centers of Competence.

According to the regulations on development and modernization of master educational programs and bachelor profiles at ETU employers (strategic partners) should take part in formation of the required competencies of graduates, as well as in curriculum development and educational program delivery.

In recent years, cluster approach has proven to be the most competitive form of cooperation and interaction for industry development. As a rule, developed innovative industrial-economic cluster is an interactive complex of high-tech companies, research and design organizations, institutions of professional education at various levels, as well as innovation infrastructure (Fig. 1).

The following ETU profile industry cluster was approved by the Government of St. Petersburg as priority: cluster of electronics, power engineering, shipbuilding, information technology and medical industry. The university has established long-term contractual relationship with enterprises and design organizations of listed above clusters, involving cooperation in the field of vocational training and skills development [2].

At the initiative of ETU the Council for cooperation of universities and industrial companies was established. It operates under the auspices of the Union of Industrialists and Entrepreneurs (RSPP) and the Council of Rectors of St. Petersburg Region. At the initiative of the Regional Council innovative program "Training and skills development for the benefit of high-tech enterprises of St. Petersburg" was introduced in 2008. It is funded by the Government of St. Petersburg. To coordinate the activities of the technical universities of the city together with enterprises of electronic cluster Innovative educational consortium was established. It has a distributed infrastructure used for the preparation of target engineering training.

Development of common information space provides a distributed cooperation network of the university with strategic partners and other Russian and foreign universities and research organizations. One of the promising features of the university regarding development and delivery of network educational programs is to provide access to scientific and educational resources, including unique equipment and software systems of Centers of Competence and Centers for Prototyping as well as the possibility of rapid communication between all participants of the educational process.

According to the definition, Center of Competence is a special structural unit of the organization, including university, which main function is to control the most important areas of activity, gathering the appropriate knowledge and finding ways to maximize their efficiency. The role of the Center of Competence is to ensure the integration of knowledge and processes that enable all stakeholders (teachers, management, students, employers) access to information resources and establish effective communication. Simply said, Center of Competence is aimed at providing opportunity for close and fast cooperation

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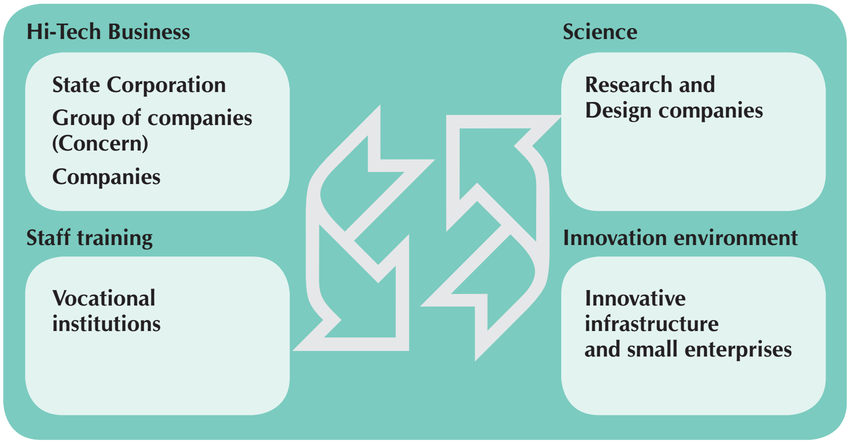
Fig. 1 Industrial-economic cluster



with each other and receiving all the necessary information to be efficient.

As practice shows Centers of Competence can be exploited in different ways, depending on the problems we need to solve.

1. Center of Competence collects best practices. The main "object of interest" for such a center - the so-called best practices that have been implemented in different areas of university activities. Center is working to identify and systematize these practices, develop relevant standards and benefit universal application of best practices.

2. Center of Competence aims to develop technology standards.

Domain-specific knowledge collected by such center covers technical field, in particular, relating to the development of software products, technologies and equipment. The aim is to standardize the process, creating a common technology platform and related data stores.

3. Center of Competence maintains numerous projects and initiatives related to knowledge management, for example, staff training on new products and services, evaluations of applied technologies, etc.

4. Center of Competence is in charge for overall integration of processes and data throughout the organization, its main purpose is to provide a global sharing of staff knowledge.

In general, Competence Center has the following functions:

- Monitoring the current state of knowledge management in the organization and provision of appropriate materials from which users will be able to find out where to get necessary knowledge and guidance - to draw conclusions about the effectiveness of this type of activity.
- Identification, formalization and distribution of tacit knowledge of the organization.
- Tracking the innovations in technology and revealing of new trends.
- Collection and description of the knowledge obtained while completing specific projects.
- Management of university knowledge base: maintenance, updating, integration, development of user-friendly search engine.
- Providing communication between users who have the necessary knowledge.
- Protection of intellectual property of the university.
- Training of new employees, sharing best practice with them.
- Distribution of accumulated knowledge throughout organization.

Establishment of Center of Competence requires a great deal of work and a significant investment of resources. However, it can bring a lot of benefits to the company: the preservation and enhancement of critical knowledge, the most efficient use of human and intellectual resources, optimal expert time allocation, and finally, solution of many business problems using its own organizational capacity.

Quite often there is an obstacle on the way from a concept to mass production of high-tech products. There could be a problem to make pre-production prototype. First of all, this problem concerns small innovative enterprises working at universities. The second major problem is the preparation of documents, that must comply with specific requirements. In Saint-Petersburg Electrotechnical University "LETI" Center for prototyping and contract manufacturing was established. The main aim of the Center is to use efficiently scientific and technological, informational and human resources to ensure the ETU contract manufacturing of high technology electronic products like the new perspective for the region shape services for prototyping and innovation rapid commercialization of ideas and technologies. It will consist of the center to design micro-and nanotech products, and laboratory-industrial complex for prototyping of products based on main components and 2D and 3D build procedures "microsystems in the body". This project will be completed jointly by the teams of research and education centers, "Micro technology and Diagnostics" and "Nanotechnology" as well as a number of departments. One of the first prototypes to be made in the Center should be miniature moving robotic systems to monitor and collect information of the main systems; chip micro laboratory for rapid diagnosis of antibiotics activity as well as projects to create the element base of radio electronics.

The three-year university experience has shown significant efficiency of using the best practices of many institutions and enterprises of the Russian Federation in joint development and delivery of the network of educational programs for graduate and post-graduate students (the university introduced more than 50 educational programs, which involved about 400 graduate and postgraduate students).

Conclusion.

To draw conclusions from gained experience of implementing tiered practice-based system of engineering training it should be noted::

- In post-crisis modernization of the Russian economy multi-level system for training engineering staff is the most appropriate organizational form of educational process at universities.
- Additional benefits can be obtained through the implementation of university-enterprise network (joint) degree programs.
- In the transition to the new Federal state educational standards and tier training system universities should undertake significant measures and innovative changes in all spheres of their activity.

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UDC 33:005.05:339.138:62
(Universal Decimal Classification)

Education Problems within Marketing in Technical Universities

Don State Technical University
B.Ch. Meskhi, T.P. Lubanova, N.N. Shumskaya

The article describes the experience of Don State Technical University (DSTU) in training engineers of higher professional education in the technological and engineering sphere who have market-engineering competencies.

Key words: *engineering marketing, scientific and technological innovation, complex engineering marketing.*

B.Ch. Meskhi

T.P. Lubanova

N.N. Shumskaya

Innovative development of today's economy is determined by its imperative technological and organizational modernization, which, in most cases, significantly depends on the discrepancy between professional and entrepreneurial (commercial) personnel training, especially engineering ones. This discrepancy within the existing economic environment is one of the reasons for the low competitive level of Russian enterprises, and consequently, the declining position of Russian businesses not only in the domestic but also in the global market.

Enterprise market engineering – advanced developing technological process of R & D innovation management based on marketing ideas and marketing ideology of engineering services throughout the enterprise business function (R&D, production, sales sectors) in respect to the objectives and tasks. Thus, market engineering provides market orientation of those engineering services governing the design, production and competitive product marketing on an innovative-base involving appropriate engineering market tools.

Market engineering is a modern marketing paradigm determining the relevant requirements to engineers. Future engineers working under today's market conditions should be the "boosters of progress" within two environments: internal environment- to design engineering problem-solving of enterprise feasibility and market demands; and external environment- to engage partners and customers in developing products and services and tailoring them to the newly-developed and changing conditions. It should be noted that such a market engineering paradigm should be determinant in Russian economy. The reason is very simple: in Russia the competitive business environment originated 25 years ago and is still developing while in industrial developed countries this environment has existed for more than a century, providing those conditions under which these countries are competitive even today.

Due to today's innovative breakthrough, engineering competency, without marketing thinking, is insufficient to further the successful promotion of any innovative product, even those products with high engineering -design parameters. In this case, market engineering is the shaping model of market thinking for engineers in the process of systematically solving engineering, management, production, economic and social problems. Marketing know-how in all engineering activity areas involves the following: (1) skillfully determining the expected consumer utility of this or that innovative product; (2) professional engineering activities within the sphere of entrepreneurship and development of technological (engineering) business.

Several years ago the International Scientific Conference "Teaching and Research in Marketing: Challenges of the XXI Century" was held at the Higher Management Institute, St. Petersburg State University, participants of which were leading Russian and foreign marketing-professionals. The discussion issues involved two problems: (1) "urgent demand in implementing innovative approaches and methods into marketing teaching; and (2) the education process questions: " What to teach?" "How to teach?" and "Whom to teach?"

In view of the above-mentioned issues, Don State Technological University (DSTU) has been conducting academic-empirical research in market engineering [1].

New marketing teaching approaches in technological universities, promoting marketing thinking education of graduates, could be the newly-developed market engineering skills for future technical & engineering personnel as there exists a direct interrelation between engineering knowledge, the product competitiveness and enterprise competitiveness itself.

In Russia project implementation through market engineering involves three important hypostases: marketing thinking of engineers, commercialization of sci-tech innovations in all engineering activity stages and meeting individual consumer requirements through engineering problem-solving.

Today, science and technology are the governing factors in the socio-economic development of any organization, as a result of the key role of scientific-technological progress in all the production spheres. The management problem of scientific-technological progress in market conditions resolves into the following problems- shaping mechanisms and formulating phases of science and technology development conformance to the priorities and values of today's and future development.

Basis for scientific-technological progress is sci-tech innovation (STI), the effectiveness of which depends on the professionalism and creativity of the enterprise engineering personnel.

Development strategies of scientific-technological progress determine the production engineering and management level and provide the basis for high-quality product output. This process involves not only such aspects as economic and marketing ones, but also the major intrinsic technological aspect as a result of updated technological and engineering innovation implementation. Technological aspect administers the development of new and/ or sophisticated products and services, while the economic aspect involves developing and changing of demand function or decrease of the production cost or both. The third (marketing) aspect embraces delivery of quality and cheap products to the consumer.

In the marketing economic environment the engineer, employing marketing as a tailoring tool of modern requirements and provision demand for priority development in conditions of intensive sustainable business competition, examines specific engineering solutions in respect to their uniqueness, dominance, importance for consumer, possible modification options, etc. As a result, market engineering becomes an integral function of the organization involved with designing, production and sales of products, post-sale services through an expanded set of corresponding marketing tools.

Linn Schostak's Molecular Model, widely applied in many foreign business sectors, is especially important in the teaching of market engineering.

At Don State Technological University (DSTU), this model is applied for term papers and graduate projects in solving any engineering market-oriented problems, including STI [2]. Marketing model of engineering activities includes:

- engineering solution " in intention" designates the objective of the engineering solution focused on the development of a new product, technology, improved quality parameters, enhancement of operational characteristics, post-sale services, i.e. the major benefit that any consumer can receive;
- engineering solution of "specific performance" - a participate form shaping the conception of the designer, i.e. what the consumer receives as a final product;
- "application domain"- assigns the possible application of sci-tech

innovation, i.e. where this proposal could be applied, either in a business or specific production facility;

- "application of IS and IT" - applying software tools (software language, operating system, GIS and others);
- "maintenance" - updating, flexible adjustment to changing market conditioned, etc.;
- "competition"- competitors with fundamental distinctions, foreign and domestic outlets;
- "benefits for the designer and / or producer" - performance increase, profits, possible qualification improvement, promotion of image making and others;
- "benefits for consumers" - cost decrease, improvement of quality parameters, performance expansion, production cost reduction, and others.

Marketing model or structural-logical project frame evaluates its relevance in terms of market orientation and system dependency on proposed solutions to:

- identify the feasibility of sci-tech innovation (engineering solution);
- determine possible business object;
- specify function of new engineering solution.

Market engineering model proposes:

- engineering solution option as entrepreneurial;
- selection of relevant economic feasibility method.

This refers to the such facts as the specification of engineering solutions, suggested not only at the R & D phase but also at the engineering and production planning phase, as well as, the application of IS and IT and etc.

Thus, based on market engineering, knowledge is translated into an effectively required market product by market-oriented engineering solutions throughout all the engineering activity steps.

According to Theodore C. Levitt "It has less to do with getting customers to pay for your product as it does developing a demand for that product and fulfilling the customer's needs" engineering solutions should be customer-oriented, and only in this case, they would be (1) in demand, (2) unique and (3) competitive.

Within the framework of the course "Marketing in Engineering Activities" the market of sci-tech innovation is considered to be a market of technology incorporating the specific characteristics of STI as a product (Fig. 1). It should be noted that like the product itself, the market of sci-tech innovation includes a set of specific features.

There are three basic elements (blocks) to determine the competitiveness of enterprises:

- effective engineering solutions within R & D and design projects;
- application of effective production technology, flexible and continuous updating of production process;
- business management marketing.

The mere engineering competency is insufficient for effective market-based sustainable business performance. In this case, nonmarketable high-quality item can become an unmarketable product. In view of this, marketing ideology is required for enterprise engineering services.

Based on the research of the existing concept "marketing mix", an "integrated metric" of engineering marketing mix, as a theoretical design and empirical approval, was introduced within the framework of the teaching course of market engineering at the Department of Economics and Marketing, DSTU. Marketing metrics is used to determine the effectiveness of an engineering solution through relevant marketing tools; while integrated marketing metrics considers them as a mix. Engineering marketing mix, a function of nine variables, (Fig. 2) is expressed as follows: EMM = f(9Ps).

The components of engineering marketing mix includes the following:

People – main source in the engineering marketing mix 9Ps; the only component which can deliver the service and determine the success of the product, as well as forecast the possible changes within the market.

Product – the physical product (functions and characteristics); product variety; product extensions through engineering mix resulting in price product catalogue.

Production – production and services, production technology (operations and processes), new technologies and relevant equipment and tools.

Price – pricing strategy is closely interrelated with the technological process and production organization where engineering solutions are predominating.

Promotion – sales promotion from producer to consumer through engineering solutions involving the most efficient promotion (in view of technology and cost loss).

Public relations – activities that promote and communicate the merits of the overall product, i.e. trademark and image-making.

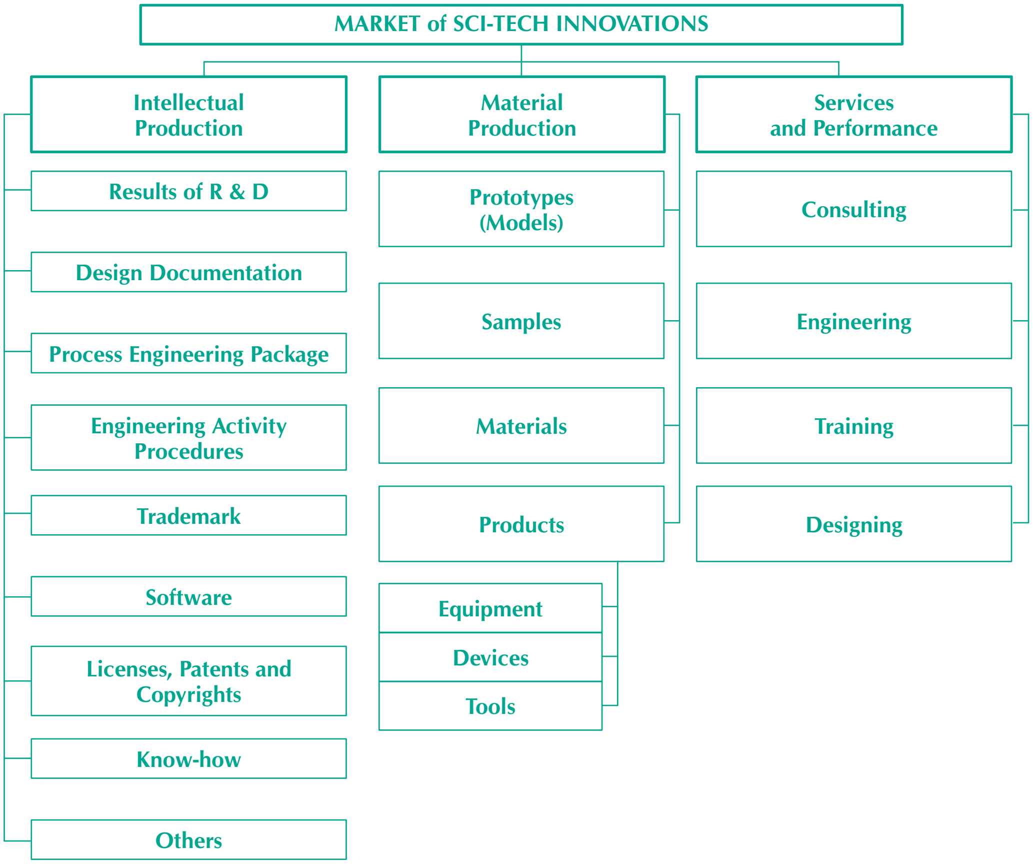
Place – company's activities that make the product available to the target market, including channel of distribution, geographic coverage, inventory, transportation and logistics.

Provider – joint relationships involving cooperation and responsibilities (new partners, negotiations, innovation information, upgrading competitiveness and improving image-making) to serve the customer's interests.

Processing – data processing through IS and IT.

Practice anticipates theory. An excellent example could be the fact that some enterprises integrate engineer-technician personnel into the marketing de-

Fig. 1. Market of Sci-Tech Innovations



partment as in Krasni Kotelschik (Taganrog) or "Gidropress" Ltd. (Omsk), where R &D vice-director (a marketing expert at the same time) heads this department. In this case, those engineering personnel with marketing thinking in comparison to marketing experts could develop competitive products for customer-demands.

Based on the University research results in market engineering new curriculum programs were developed in training future specialists: in 2010- engineers in specialization 151001 "Engineering Technology",151001.28 – "Marketing and High-tech Technology" and in 2011 Bachelor degree programs – 150700 "Mechanical Engineering" including the module "Market Engineering". To improve engineering- technical human resources in different regional enterprises, updated education programs in "Market Engineering", oriented for engineering service personnel in developing relevant marketing competencies, have been developed and implemented. The following professions have been introduced in Russia: planning engineer-marketing expert; planning engineer - analyst; planning engineer- researcher; design-engineer of innovative technological equipment and tools and other professions.

Specialists in engineering and technology and market engineering-oriented, with working experience in enterprises can:

(1) be market- competitive;

(2) advance the prestige and image-making of DSTU, the technological university training specialists in marketing.

Fig. 2. Engineering Marketing Mix

1. People: ▪ contacts and meaning of the customer; ▪ participation the of consumer in the production process; ▪ personalization of consumer (customization)	2. Product: ▪ product quality; ▪ wide range of products; ▪ innovation as an integrated element in product designing and marketing ▪ packaging ▪ industrial design	3. Production: ▪ innovative production mode; ▪ flexible production process; ▪ sci-tech innovation	4. Price: ▪ pricing strategy based on engineering solutions
9. Processing: ▪ application of IS and IT in market-oriented engineering activities	ENGINEERING MARKETING MIX- 9Ps		5. Promotion: ▪ engineering solutions in further promotion; ▪ provision of technical input
8. Provider: ▪ information access for engineers; ▪ database approach; ▪ online, questionnaires, web-sites and associations	7. Place: ▪ market coverage and distribution channels; ▪ maintenance service		6. Public relations: ▪ image -making of the enterprise; ▪ competitiveness; ▪ participation of engineers in PR campaign

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UDC 355.237:622.276
(Universal Decimal Classification)

Experience in Staff Training and Development for Solving Design and Engineering Problems in Petroleum Industry

JSC "TomskNIPIneft"
I.N. Koshovkin, A.S. Latyshev, A.G. Chernov

The article describes oil companies' basic requirements for modern engineers who work on designing and development of oil and gas fields. It analyzes and suggests the most optimal ways of interaction between Higher Education Establishment and Enterprise in the sphere of design engineer training. The example of the scientific-research institute shows practical implementation of business-education interaction concepts. It also describes basic approaches to effective staff development and training programs being put into practice.

Key words: *engineering training, project, designing, competencies, establishment, staff training, higher educational institution, engineer.*

I.N. Koshovkin

A.S. Latyshev

A.G. Chernov

The staff shortage issues in the solution of petroleum engineering problems. Today, different research and development institutes play a central role in the current development of oil and gas industry. However, it should be noted that their main activity areas have undergone significant changes over the past few years. On the one hand, they are affected by the experience of international petroleum companies which provide almost all engineering services in their subsidiaries, i.e. reservoir development, feasibility and conceptual study work, while design and construction of surface facilities are operated by independent companies under the construction contracts. On the other hand, those Russian organizations which provide the same services are in most cases research institutes organized in a completely different way. Their emphasis remains on the delivery of traditional reservoir engineering projects, in particularly, oil and gas reserves estimation, feasibility study of oil and gas-oil fields development techniques, geological and hydrodynamic modeling for reservoir simulation, and oil and gas field development planning. In addition, such institutes also provide field geology services for oil and gas exploration work planning. It is obvious that the main competencies to be acquired by the employees to correspond to the above-mentioned job requirements should be based on the application of such up-to-date field development technologies as formation breakdown, enhanced oil recovery, wellbore sidetracking method, lateral drilling technology and etc. Besides, the real-time measurements-while-drilling (MWD) has already become one of the most widely implemented technologies in recent years. To address the deteriorating decline in oil and gas reserves, the application of the above-mentioned methods is commonly based on the vast implementation of computer and technical information technologies in field modeling.

Design and survey work is another area of the institutes' activity which basically includes the development of all required design and estimate documentation. In the middle of the 90s, the customer relationship was managed through the following pattern: the pre-feasibility study ("What to build? Where to build? Why to build?") was carried out by the customer himself, while the institutes were engaged in project development. That's why, while being implemented, the project technical specifications were frequently changed that increased project costs and implementation period. It became even more critical in regard to the large-scale projects launched in the Eastern Siberia. There were high probabilities of project implementation failure. To solve the problem of interaction between research and development institutes and a customer, a definite set of competencies, in particularly conceptual engineering and development of tomorrow's technology solutions, should be acquired by institutes' employees. Conceptual engineering is the first stage that makes up an engineering project. This is the phase in which the desired objectives are set, as well as technologies and alternative cases are defined under the standards that regulate the project including the economic evaluation criteria and calculation of profitability. Being a rather specific type of engineering work, conceptual engineering is based on the concepts of science, manufacture and consulting service, thus, providing valuable technical basis and highly motivating work environment for the employees involved in project development. Today, conceptual engineering is being increasingly used in solving engineering problems which can arise within completely different projects or at different stages of project implementation, i.e. regional level (oil and gas bearing region) or local level (booster pump station) [1]. Analysis of technical options and selection of the technology applicable to the project are the most essential stages of conceptual engineering. In the current energy efficiency policy, appliance and equipment energy efficiency has become one of the most critical aspects. As new oil and gas fields are being intensively developed, there is a need to search for a new conceptual approach and hydrocarbon production strategies within the regional framework. Based on the obtained results, the law of the Russian Federation could be amended with due regard to tax privilege, as well as government and private sector interaction concepts. Special consideration should be given to the conceptual projects focused on the existing industrial facilities. The specialists of the research institutes address the current engineering bottlenecks and propose the solutions to improving and developing infrastructure projects based on the definite customer needs and thorough analysis of the existing engineering infrastructure.

Taking into consideration all above mentioned facts, the present-day companies providing science, research and development, and other technical/engineering services to petroleum enterprises pay special attention to such employees' competencies as conceptual engineering and ability to provide technical solutions for surface infrastructure development. It has become obvious that such institutes should have sufficient human capacity (chief engineer as a head of a project) and capability to execute projects in such a way that the desired objectives are clearly set, basic technical solutions including implementation period, project costs and efficiency, as well as labor force and risk assessment are carefully outlined [2].

A new model of engagement sets new requirements towards employees' competencies. To solve the current technical problems, just-graduated young engineers should possess deep multidisciplinary knowledge in field exploitation, analytical and project documentation development, engineering evaluation and basic process simulation, as well as to be savvy in topics as wide ranging as geology, fluid mechanics, thermodynamics, physics, mechanics and etc. To sum up, it should be noted that the shortage of highly-qualified petroleum engineers has become a critical problem which could lead to rather serious complications in business performance [3] and it primarily concerns research and development institutes and departments.

Training evaluation of engineering students with respect to industrial standpoint. Engineering education in Russia is likely to undergo "severe and systemic crisis" [4], according to different sources and the estimates provided by the experts of Association of Engineering Education of Russia (AEER). Despite the popularity of this statement, the representatives of higher educational institutions can hardly agree with it. Russian higher education is still believed to be one of the best educational systems in the world. Without passing any judgment on this or that point of view, the employees of JSC "TomskNIPIneft" are working on the development of the program of the competency-based staff training which would meet the institute's needs. To achieve this, it is essential to find out what kind of knowledge and competencies a present graduate is lack of.

Today, it is not a difficult task to attract young and talented specialists to oil and gas industry and petroleum institutes. The problem lies in the gap between employer's requirements for graduate skills and the level of a graduate knowledge acquired during an education period. Therefore, the evaluation of university performance based on the number of applicants per place may seem to be efficient within the framework of the whole higher educational system. However, the application of the same evaluation approach to assess the quality of a subject in all study programs that the subject is taught is not quite correct. Higher educational institutions are trying to figure out the requirements and evaluation criteria to their activity, but in most cases it is done in respect to the educational standards of higher educational establishments. The existing qualitative and quantitative differences in the educational programs concerned have induced us to evaluate not only the material and technical facilities involved in the training of our potential employee, but also to assess the quality of the methodologies and learning tools applied, as well as knowledge and attitudes of the teaching staff. Examination procedures, laboratory work and course papers focused on the solution of real technical problems are also of great importance to us as it is an integral component of interaction between research and development institutes and higher professional establishments. Unfortunately, the representatives of higher educational institutions are not likely to use the criticism as a motivation to cooperate within quality assurance in higher education. There is a widespread belief among them that a potential employer must only provide financial support, while university is capable of assuring high level of knowledge alone. However, the interaction between higher educational establishments and potential employers aimed at improving of learning techniques and procedures is a rather important component.

We would also like to discuss the lack of any real inflow of young teachers and professors at the universities. There is a deeply rooted belief that low-income level of teaching personnel is a fundamental reason for the shortage of young specialists at educational establishments. However, low salary is not the only reason and, probably, not the main one. In most cases, the major reason is explained by the unwillingness of the older generation to change something, to look for new perspectives and development programs. Instead, teachers and professors prefer using quite old teaching materials which were important several decades ago. Training and learning materials are not revised in the course of time. There is no approved procedure to bring the study materials of lecture courses, lab works and course papers up to date so that they are almost completely revised once per five years. We have a right to evaluate the situation in a very "rough" manner as we have faced just the same problem while preparing study materials for staff retraining project tentatively titled as "Surface Infrastructure Development". We developed learning modules of the subjects, specified the requirements for subject content and study materials. However, not all professors and teachers were ready to be involved in the development of new learning materials. Instead, they were trying to convince us to accept the already-existing teaching resources. Due to these difficulties, the project was launched a year and a half late. The same problem was encountered when learning materials were being developed for module "Ecology for Petroleum Enterprises" taught at Herriot-Watt Center. Because of the mentioned problems, young specialists have no any possibilities to realize their potential in the near future. Also, bureaucratic red-tape which has become a common place in higher educational establishments is rather noteworthy. One of the major problems lies in the fact that evaluation of university performance is mainly defined by the quality of prepared reports and documents required for the assessment procedure. Therefore, universities aim their efforts at the process of preparing documents rather than at the revision of study materials content that is considered to be unimportant.

JSC "TomskNIPIneft" approaches to solving the issue. We strongly believe that the only way out from the current situation is the implementation of long-term target programs aimed at developing higher engineering education and technical industries [5] in Russia.

To address the problem, we propose to consider the experience of JSC "TomskNIPIneft" in developing cooperation between entrepreneurs and universities, as well as to discuss the approaches for improving the quality of engineering education and reducing the impact of qualified staff shortages. Indeed, petroleum engineering is no longer a profession which is limited by one or two subject areas. According to the current trends, an employee of research and development institutes needs to correspond to the requirements of the 21st century, the era of network and information technology. In the 21st century, an engineer needs to be increasingly multidisciplinary, capable of handling a vast range of interdisciplinary projects, implementing up-to-date innovations and technologies, generating new ideas and engineering concepts. Such specialists should be ready to broaden their knowledge in scientific and technological environment demonstrating engineering problem-solving skills and attitudes for successful project design, implementation and management. They are also expected to develop conceptual design solutions and apply technological tools.

JSC "TomskNIPIneft" is involved in many large-scale strategic projects focused on staff development and engineering education quality improvement. It can be explained by the fact that in order to succeed in the development of production facilities in the perspective regions of the Russian Federation, it is essential not to send the employees to different retraining courses but to get them engaged in target-oriented educational projects implemented in cooperation with higher engineering institutions [5].

In our opinion, cooperation between an enterprise and universities in solving the above-mentioned problems of engineering education can be achieved through one or more of the following:

- Implementation of special education programs intended to facilitate the unique interdisciplinary training of elite engineers capable of addressing emerging technical needs while studying at university.
- Integration of engineering education, science and business.
- Launching of cooperative short-term retraining projects aimed at developing young engineers and scientists to meet modern industry's requirements.

Evaluation of young people's motivation. Before launching any training or retraining programs, it is essential to understand the motivations of young people who these programs are intended for. Note, the survey carried out in our institute shows high level of satisfaction among employees with education system and retraining programs (61-68 % of respondents are satisfied with the results of education). Meanwhile, the same results reveal quite low motivation level of employees to take the positions which require a high level of responsibility. This brings up the questions: What do engineering employees need? What kind of learning styles and materials can appeal to them? It is required to find out whether they are motivated to study or not. The answer of young people to such question as "why do they study?" is as follows: "as work and possibility of further self-development are important, we need to gain additional knowledge to progress up the career ladder".

It is interesting to note that we usually create the challenges for our employees trying to motivate them to continue studying and improve their skills in order to solve the problems being set. For example, a curriculum of the educational project entitled "Surface Infrastructure Development" includes 1400 hours and 13 technical and 10 management modules. The staff (JSC "TomskNIPIneft) may have the right to request time off work for training or study or combine their study with work. However, it does not influence the number of applicants who wish to complete the program.

Based on the analysis of young specialists' behavior patterns and different survey results, it can be stated that not only industry representatives but also highly-motivated students recognize the insufficiency of engineering graduate education. Many students are trying to get job while studying in order to gain experience and practical skills within their future qualification. Those students, who are trying to pursue two or even more programs simultaneously, i.e. advanced foreign language training or economics, are worthy to be praised. However, it sounds like a reproach towards university, as it is not able to provide students with qualitative education within the program being chosen.

Our conclusions concerning the high level of successful students' motivation coincide with the opinions of those who investigate the same processes in youth environment [6]. Eventually, it is precisely this focus on professional growth that becomes of great importance in selecting the candidates to be promoted up their career ladder [1].

Engineering staff adaptation training and development. In our opinion, to improve the quality of engineering education, industry must make provision for consistent development and implementation of engineering projects aimed at enhancing not only technical skills of the specialists but also communicational, creative problem-solving and managerial attributes. The approaches designed by JSC "TomskNIPIneft" to solve these problems are discussed below.

Implementation of elite engineer training as a university program adapted to modern industry's requirements. Engineers are one of the most required professions in modern Russia. However, those enterprises which focus on the reduction of average age of employees come across with the fact that young engineers being rather knowledgeable in science and engineering fundamentals which in most cases do not correspond with real industry's needs have no enough experience and practical skills in the application of technological tools. As a result, a just hired engineer needs to adjust their level of competencies to the real technological needs, which can require 5-6 year period so-called "period of inactivity". The problem discussed is not the new one. It is frequently addressed in various conferences and meetings where industry and academics share their opinions. Standard internship programs are no longer the way out from the current situation.

JSC "TomskNIPIneft" proposes to tackle the discussed challenges by implementing target-oriented training projects intended for highly-motivated students who will be subsequently employed by the company sponsored the project. The cooperative effort of business and universities in implementation of such projects is of great importance, as it can help to reduce the costs of program's initiators while improving quality and increasing employment opportunities for young engineers. In this case, the name project implies module-based training programs adapted to the current industry's needs. To enroll in these programs, senior students have to undergo the evaluation procedure (academic progress, SHL, competency tests, motivation questionnaire and interview). Besides Diplomas of Higher Education awarded at the end of studies, such students will also obtain up-to-date knowledge concerning engineering practice. It can reduce a vocational adjustment period required to a student to adapt his competency level to the current technological process.

Modern adjustment programs designed to help young engineers to enter the industry: social, engineering, scientific programs of development, experience of JSC "TomskNIPIneft". In such a rapidly changing technical environment, an engineer should be capable of conducting independent scientific research and creative activities, producing competitive goods and generating ideas and solutions.

Thus, a modern employee is characterized by a definite set of competencies, high motivation and qualification. At the same time, the adaptation models implemented through two levels (level of personality – employee himself – and level of enterprise – staff management) [6] have become of great importance under the current conditions. In this context, professional adaptation is termed as a definite period when it becomes essential to ensure that young engineer is informed on his workplace, range of duties and all relevant rules and values inherent in the workplace and enterprise itself, as well as some guidance as regards possible promotion and improvement of qualifications.

Based on the results of regular surveys among young engineers of JSC "TomskNIPIneft" and comparative analysis of similar data obtained in other research and development institutes, it could be stated that adaptation of young workers to the workplace depends on a number of professional, psycho-social and communicational factors. Figure 1 provides a detailed description of the factors including weight indexes which reflect survey results obtained in 2011 -2012. Approximately 200 respondents were to choose three negative factors which, in their opinion, had a detrimental effect on the process of adaptation of a young engineer to his workplace.

The most negative factors are as follows: unfitness for the work duties, housing issues, communication problems, failure to understand company's mission and objectives, absence of mentor and neglectful attitude of immediate head. Therefore, the focus should be made on all-round development of a specialist in order to achieve in a very short time one of the most important goals – to provide rapid professional growth of an employee to meet the changing global environment. To achieve this, enterprises should launch professional and social adaptation programs aimed at handling the following tasks:

- rapid acquisition of professional knowledge and technical skills;
- independent performance of job duties;
- job satisfaction;
- all-round development of innovative and scientific potential;
- observation of workplace discipline and rules;
- self-development;
- development of communication skills to work with colleagues, suppliers and partners.

JSC "TomskNIPIneft" has created a three-stage training program for young specialists including individual development plan and mentorship. Each young specialist must follow individual development plan which is extraordinarily important to the company's stable long-term growth. It consists of a number of compulsory modules and modules which are defined by a mentor assigned to a participant of the program. The program has several main components:

adaptation, professional and personal development, acquisition of innovative, research and engineering potential and motivation. Table 1 shows the stages of the training program for young specialists designed by JSC "TomskNIPIneft".

Each year the company organizes different scientific seminars where young specialists have the opportunity to demonstrate their capabilities and display their innovative ideas facilitating communication strategies and shortening their adjustment period. A professional jury consists not only of institute employees but also representatives of universities and scientific schools. Judges can objectively evaluate the projects which young specialists present giving valuable advice concerning theoretical originality and the quality of the projects themselves. Besides, the institute holds large-scale conferences which attract great number of experts from the industry's large universities and scientific schools, individuals from research and development institutes and petroleum companies. Employees of JSC "TomskNIPIneft" always participate in different scientific and research activities. It helps to support and develop the interaction between business, science and education which is of great importance to the institute.

Objectively, the implementation of adjustment programs based on the world-wide experience which are aimed at adapting young specialists to new professional environment could significantly contribute to rapid acquisition of professional knowledge. This will provide the company which focuses on the quality of engineering staff, innovative technical solutions and inventions with competitive advantage.

Cooperative projects aimed at retraining and development of young engineers. Today, engineering education is failing to confront the new challenges in the rapidly changing field that constitutes engineering, especially oil and gas industry in today's global environment. It is possible to state that the tendency to disintegrate education from the production and economic processes which emerged in the 90s of the previous century has significantly contribute to the current situation when standard engineering education is producing a different engineer to that desired by industry, and that engineering education does not meet modern labor market demand. Being developed in accordance with old-fashioned standards, educational programs mainly include only science fundamentals: knowledge of the basic laws, concepts, theories and principles of science.

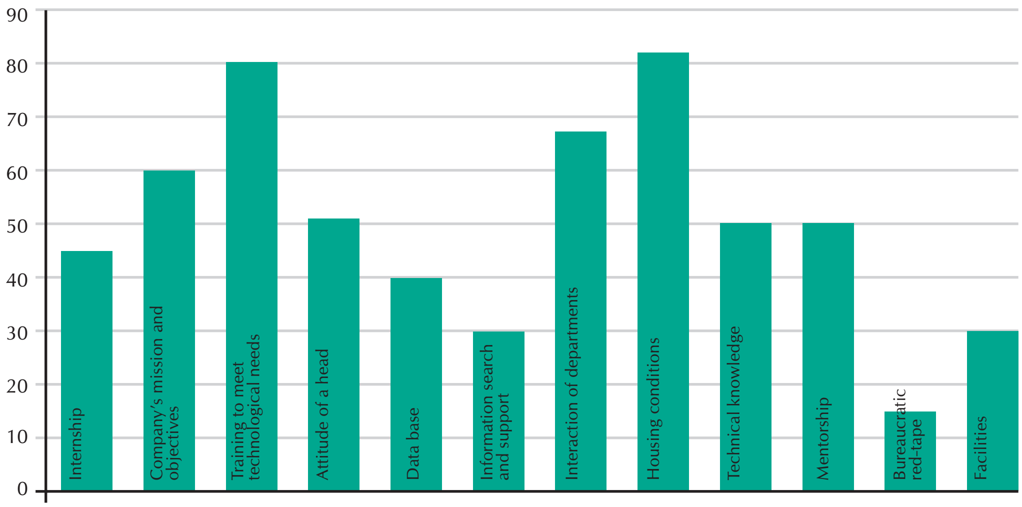
Besides the development of traditional ways of interaction between enterprises and universities, JSC "TomskNIPIneft" insists on implementing the strategic projects aimed at training engineers for scientific and design departments of the Institute, which are more deeply integrated into the learning process. More detailed information about the implementation of such project can be found in previous publications [5].

Cooperation with universities to integrate engineering education with scientific activity of research and development institute. Cooperation with universities has been always of high priority to JSC "TomskNIPIneft". Besides the discussed staff training programs, joint efforts are also made to enhance traditional learning styles and develop new framework for cooperative project implementation.

Whatever the type of interaction, it is directly or indirectly intended for training engineers capable of solving innovative tasks encountered by research and development institutes and petroleum companies.

1. The existing scientific schools affiliated to universities are attracted to fulfill the current agreements. Tomsk Polytechnic University and Tomsk State University are strategic partners of JSC "TomskNIPIneft". They are involved in analytical studies, core research, reservoir simulation modeling, and etc. In 2012, a new project was launched based on the cooperation of the institute and one of the departments of Tomsk Polytechnic University, i.e. Design and

Fig.1. Important Factors in Young Engineer Adaptation Process



Research Institute, to make provision for design specifications and estimates. To perform such kind of work not only teaching staff and post-graduates but also students are attracted. It helps them to understand the current needs and requirements of petroleum companies, while university gets the possibility for further development and growth.

It is interesting to note that due to the Federal Program most universities are well equipped with modern facilities and computer instruments. However, all this equipment is not adequately applied, especially, for handling innovative challenges. In this case, it is precisely

Table 1. Three-Stage Training Program for Young Specialists

Type	1st stage	2nd stage	3rd stage
Adaptation	Adjustment courses History of "TomskNIPIneft" Mentor Individual development program (1-2-3)	Team training classes Business games Participation in young specialist working groups Student Internship	Business games Participation in young specialist working groups Student Internship Traineeship Personnel reserve
Development	**Training classes:** Time management Effective communication **Education** Fundamentals of oil and gas field development Fundamentals of oil and gas field surface facilities construction Modern software	**Training classes:** Team work Presentation Systems thinking **Education:** Project Management Special programs Technical course	**Training classes:** Evaluative training class Management fundamentals **Education:** Advanced courses Special projects Traineeship
Research	Postgraduate student support Scientific work support team Possibility to participate in different conferences	Postgraduate student support Scientific work support team Participation in different conferences	Participation in different conferences Dissertation Possibility to teach and develop learning modules
Motivation	Compensation for rental housing Benefits for research and development project Young specialist forum Sport and cultural activities	Development of social support program based on research and development results Benefits for research and development project Promotion	Development of social support program based on research and development results Benefits for research and development project Promotion Recommendations for Personnel reserve

industry research institute that can set the tasks, as it has deep understanding of many field technical problems and, as a result, it can contribute to their solution. The establishment of Core Research Laboratory on the basis of Tomsk Polytechnic University is one of the examples of such cooperative work. The laboratory corresponds to the modern requirements of petroleum companies and research and development institute's demands. Therefore, teaching staff and graduates have an opportunity to enhance their professional skills while performing close-to-life analysis and research.

2. The employees of JSC "TomskNIPIneft" are also involved in teaching activity almost at all universities of Tomsk – Tomsk Polytechnic University, Tomsk State University, Tomsk State University of Architecture and Building. Today, more than 20 specialists of the Institute give classes on different subject areas trying to instill the students with those skills and attitudes which are required by engineering enterprises. Each year more than 50 graduates are interned in "TomskNIPIneft" and even more students visit the Institute to get acquainted with its activity areas and research facilities. One of the objectives to be achieved in 2012-2013 is the development of retraining programs within a broad field embracing design and engineering activities which will be included in the joint project of "TomskNIPIneft" and Tomsk Polytechnic University aimed at enhancing professional skills both of specialists and promising students.

3. Institute also takes measures to support research activity of its employees, especially scientific work of young specialists. The current staff estimates 37 candidates of science, 1 doctor of science, 30 post-graduate students. Four dissertations were defended during the last two years and two dissertations were expected to be defended at the end of 2012. Dissertation research is performed with the assistance of university scientists that emphasizes close relationship of Institute and universities. The employees holding scientific degrees often become head managers of research and development projects. Though amount of such work is not great at this moment, this field is proved to be rapidly developing. And, it is already well-known fact that specialists who have graduated from university and undergone the special "TomskNIPIneft" training program more easily familiarize with new activities and become good mentors for future engineers.

4. "TomskNIPIneft" provides necessary support for student training. Teaching methodology developed by the specialists of the Institute is widely applied in learning process. The Institute also provides universities with research materials required for scientific work, in particular core analysis. For example, due to the contribution of the Institute a great number of core samples were collected in Tomsk Polytechnic University. Earlier, it provided financial support to equip computer classes with modern software required for field development modeling. All this, undoubtedly, helps young specialists to adjust quickly their professional skills to real industry's requirements and tasks.

The experience of the Geochemistry and Reservoir Oil Laboratory is worthy of notice. Each year not less than 10 students are interned in the laboratory performing basic duties and solving everyday technical tasks. They get acquainted with institute structure, its activity areas and research work peculiarities. As a result, the best students are employed to the positions they have already known. Besides, they have a possibility to keep a contact with the university by entering a post-graduate course. Their scientific work contributes to the quality not only of the Institute activity but also of engineering education, in general.

CONCLUSION

For many engineering enterprises, it is an obvious fact that modern leadership is impossible without the development of high technology industries and services which efficiency, in its turn, is directly determined by the level of engineering education and professional skills of engineers and inventors.

Such leadership can be achieved by launching practical research projects and establishing world- class production-and-training centers. The role of the government is also of great importance as it can provide engineering education with strategic support to assure the inflow of young specialists to industry and higher educational establishments.

Being representatives of industrial sector and research and development complex, we should realize and assume the responsibility for improving the system of engineering education in modern Russia. In order to prepare engineers to meet new challenges, engineering training and education must be revised and modernized. Changes to the existing curricula should be based upon modern learning techniques, active involvement of teaching staff and students in solving technical problems and engineering tasks.

In 2012, JSC "TomskNIPIneft" launched the project intended for training elite engineers to participate in conceptual engineering, design and survey work. Besides, short-term training modules on a vast range of subjects including design and development, fundamentals of economics and project management, students will have an opportunity to obtain assistance of the experts in:

- learning project fulfillment based on real data;
- engineering knowledge application during internship;
- team project implementation intended to meet current industry's needs.

This kind of learning process allows students to work hard within authentic constraints, compare and evaluate their technical solutions against real-world industry and perform real-life engineering with the help of their scientific advisors. The project is expected to be implemented in partnership with several Tomsk universities and research institutes.

The consistent integration of such projects in the learning process can significantly reduce the adaptation period of a young specialist who in most cases has not enough knowledge about real-life industrial problems, modern information techniques and software, company's principles of organization and interaction. Above all, it will provide universities with required facilities which can be of great importance in the integration of industry with the learning process and contribute to the improvement of engineering education.

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UDC 378.147
(Universal Decimal Classification)

Integration of Engineering Education with High-Technology Business (by the of ISTU)

National Research Irkutsk State Technical University
I.M. Golovnykh

Nowadays the strong competitiveness for the qualified engineers exists on the labor market. Business and modern level of production allow raising a demand to the quality of the staff training while the existing system of higher professional education continues to graduate specialists who are not very well prepared to the production activity. The solution of the problem is to join the efforts of technical universities and big high-technology companies.

I.M. Golovnykh

Key words: *engineering education, satisfaction of requirements of business societies, partners-employers, confidence in the professional career, discharge of R&D by order of high-technology business.*

National Research Irkutsk State Technical University is one of the largest universities in Siberia. More than 23 000 students (92 – Specialist's degree, 39 – Bachelor's degree, 19 – Master's degree) study at the university. It offers a challenging intellectual environment with 150 graduate and 30 undergraduate degree programs. Among those who teach and do research at ISTU there are 123 higher doctoral degree holders and almost 630 holders of candidate degrees, the total number of professors and instructors being about 1 130.

The university has over the past 82 years trained more than 145 000 specialists, with 2000 being foreign students. Its alumni constitute 70% of engineering industry and 50 % of high-top and mid-level managers in leading companies of Irkutsk region.

Effective collaboration of ISTU with industrial enterprises is one of the most important factors for its success. Earlier, this kind of relationship worked only one way. However, the situation has significantly changed over the last 5-6 years. The representatives of industrial enterprises and potential employers become actively involved in discussing the ways to handle the problems in engineering education. It can be explained by the rapid development of real economy sector that led to the staff shortage especially in high-tech field. High average age of workers and lack of knowledge in application of up-to-date technological tools are the current "pressure points" in engineering business. The shortage of qualified personnel is also aggravated by low level of young people mobility.

Besides, low level of student motivation also negatively affects educational and professional achievements especially in the field of science-driven and high-tech industries which are still characterized by low salary level and slow career progress. Today power engineering challenges outflow of specialists to oil and gas industries [1,2] as they are searching for better working conditions and remuneration's reward. There is strong competitiveness for engineers among different enterprises and industrial sectors, as well [3,4]. The shortage of qualified personnel can be also explained by rapidly changing requirements of modern engineering environment. Contemporary engineering is a profession directed towards the application and advancement of professional and practical skills based upon the deep understanding of up-to-date technological instruments and communication tools [5]. Besides, as companies have to enter foreign markets, their employees must acquire additional professional skills to localize their products so that they can compete with international companies. There is also another problem to be solved, i.e. to accord federal state educational standards of higher professional education with professional standards which have emerged in different fields of high-tech industry, for example in aircraft engineering [6] and communication technologies [7]. Today, most employers are not able to figure out the requirements a modern engineer to meet and as a result engineering education fails to produce a specialist that desired by real-life industry.

On top of this, old-fashioned material and technical facilities of higher engineering establishments can hardly contribute to the quality enhancement of engineering education.

To address emerging challenges concerning staff shortage and quality improvement of engineering education, it is essential to join the efforts of technical universities and large engineering companies focused on competitive and high-tech production fields of national economy. Such kind of cooperation will allow higher education to produce a specialist equipped with necessary professional skills to confront new challenges and who will be ready to move and contribute to his personal development. This way is also followed by the developed countries. For example, most part of US universities is private-sponsored. Large international companies invest money to the perspective universities in order to train highly-qualified specialists for their business [8].

Based on ISTU experience, the following types of effective cooperation which will assure training qualified and highly-demanded specialists can be distinguished:

1. Monitoring quality dimensions of engineering education and types of profession being in demand. ISTU offers its students many job placement opportunities through the successful implementation and development of job placement programs. During the whole academic year, staff of the job placement department is seeking for large-scale engineering companies which can easily become potential employers of university graduates. They are asked to inform university about professions being in-demand, working conditions, social security floor and even the assessment of teaching quality provided by the university. In 2010/2011 academic year, more than 300 inquiry letters were sent to large-size and middle-size engineering companies. Based on the obtained results, the staff of the placement department builds up the vacancy database and forwards it to Deans of the faculties or Directors of the institutes. The latter, in its turn, annually examines the results of job placement rate and develops the corresponding corrective action plan.

The detailed information about vacancies and companies is accumulated in the commissions of the faculties and institutes. The vacancies are distributed among the students based on the GPA being achieved (excluding personal agreements and contracts).

Thus, when graduating from university, young specialists are awarded with Diploma and job placement document.

Engineering curricula and learning materials are annually revised by the heads of the departments to adjust the training process to the ever-changing employer's requirements.

The existing system of monitoring allows university to obtain true-to-life assessment of its activity as well as to determine what is needed in the future design of engineering curricula to produce the specialists who will be always in high demand.

2. Development and implementation of educational programs on demand of potential employers. In order to prepare engineers to meet new requirements of business environment, ISTU is striving to accord the standards of the existing curricula of various educational programs with the needs of employers.

In 2011, as information technologies play a key role in design and production of high-tech and HVA products ISTU developed its own educational standard for the learning module "Information systems and technologies" in cooperation with Irkutsk Aircraft Plant (branch of IRKUT Corporation), "Irkutskgeofisika" Inc, "Irkutsk Electroprospecting Company" (IERP). Most information technologies are common in structure, although the application procedure will significantly vary depending on industry field. This fact is not considered by the existing Federal State Educational Standards. Our partners-employers were constantly anxious about the fact that a young programmer just graduated from university had to undergo quite a long adaptation period to adjust his professional skills to real workplace requirements. According to their comments, ISTU has developed the educational standard which makes possible not only to meet the needs of high-tech enterprises for the specialists equipped with necessary professional skills but also to instill additional confidence in graduates within their field of study. New educational standard has been developed on the basis of the existing Federal State Educational one. However, new scientific-and-teaching cycle has been added, additional learning outcomes according to activity areas have been specified and new professional competencies relevant to real workplaces have been outlined. There are 12 compulsory subjects (throughout all cycles) and 38 additional criteria for evaluating learning outcomes.

To facilitate the practical application of knowledge acquired, ISTU alongside with Tomsk State University of Control Systems and Radioelectromics [9] has made a resolution to approve the content of educational engineering programs with the biggest employers of the university graduates. This important step will allow higher education to produce a specialist equipped with necessary professional skills to meet the requirements of modern engineering companies.

In 2010-2011 more than 470 educational programs were developed and accorded with the biggest engineering enterprises and research institutes operating within high-tech sector of national economy. They are: "Irkutsk Aircraft Plant (branch of IRKUT Corporation)", JSC "Angarskaya Neftekhimicheskaya Kompaniya", JSC "IrkutskNIIhimmash", JSC "Russian Railways", JSC "East-Siberian Biotech Combinate", JSC "Irkutskenergo", JSC "Irkutsktyazhmash", JSC "Buryatzoloto", LLC "Vostochno-Sayanskaya Nikelevaya Kompaniya".

The same work is also being carried out in concern with further vocational education programs. In 2010, 64 newly-developed educational programs were added to the list of 132 curricula. In 2011, more than 5 000 employees of different engineering companies did the refresher courses at the university.

3. Establishment of research-training centers sponsored by industrial companies. At the present moment, this kind of interaction of engineering education and high-tech business is considered to be completely new and rather efficient.

In ISTU, there are two research-training centers supported by well-known fuel and energy companies - "TNK-BP" and JSC "Irkutskenergo". The main objective of the centers is to train qualified specialists in accordance with the programs approved by the experts of industrial companies. Besides acquiring specific technical competencies to adjust a specialist to his workplace, attending the courses brings important social and networking benefits to each attendee. The programs are designed to keep employees' skills up-to-date and develop their talents to perform research on the relevant topics.

To meet the requirements of the company to the training quality and to enhance not only technical but also soft-engineering skills, TNK-BP research-training center offers the following educational programs: fundamentals of petroleum engineering (for non-majors); basic concepts of earth science: oil and gas field development and etc., with such learning modules as "Introduction to the Company", "Career growth in TNK-BP", "Success with TNK-BP " and business game "Three Horizons" being of great importance.

Each year more than 1000 workers of petroleum companies located in Eastern Siberia improve their qualification in the research-training center.

The center is equipped with full-scale simulator DrillSIM-5000 which allows us to implement completely new learning style enabling trainees to develop technical skills and execute real world drilling or well control exercises, prevent and mitigate emergencies and encounter the showings of oil-gas and water. The attendees are rewarded with international certificate entitled "International Well Control Forum". To maintain high level of learning process, two employees of the university were interned in the training centers of Aberdeen Drilling School in Scotland and were awarded with assessor and supervisor certificates which gave them the right to train specialists in accordance with IWCF standards. In 2009, ISTU became a member of International Well Control Forum.

In 2012, full-scale simulation center was acquired due to the financial assistance of "TNK-BP". The simulator offers immense flexibility in the software and simulated drilling equipment to drill a well equipped with electrical submersible pumps. It is also planned to establish training ground where it could be possible to launch simulating modules designed to enhance understanding

of the fundamentals applicable to operation and maintenance of different oil and gas field facilities.

JSC "Irkutskenergo" research-training center offers a number of enhanced educational programs designed to provide students with deep knowledge in the following modules: installation, operation and maintenance of heat engineering facilities and network; equipment of electric power plants; automated control systems of thermal stations; protection equipment and relay ladder logic system of plant equipment and machinery. High quality of teaching process is provided by the experts of JSC "Irkutskenergo", leading educators of Melentiev Energy Systems Institute of Siberian Branch of the Russian Academy of Sciences (ESI SB RAS) and teaching staff of power engineering faculty.

The center includes Equipment Protection Laboratory and Electromagnetic Compatibility Laboratory which are equipped with the state-of-the-art fixed installations and portable devices – consoles of relay protection and automated control system manufactured by leading Russian and foreign companies. In the short term, it is expected to establish new electro-technical laboratory equipped with a full-scale simulator of electrical power unit.

One of the basic learning techniques widely applied in research-training centers is a team work which is based on the results obtained in current research ordered by the companies-partners.

4. Attraction of young specialists by organizing company presentation and launching scholarship programs. Through the established partnership with our partners, we are able to successfully interact in questions concerning the ways of attracting young specialists to work in industrial companies. We usually hold the meetings where the managers of the companies provide students with information about the company, its history and mission, working conditions and career growth. Such meetings significantly motivate students to study and acquire professional knowledge. More than 60 meetings were held during the last three years: "Irkutsk Aircraft Plant (branch of IRKUT Corporation)", OJSC "Norilsk Nickel", JSC "Arsenyev Aviation Company PROGRESS"; JSC "Kolskaya Mining-Metallurgical Company", JSC "TNK-BP", CJSC "Alrosa", OJSC "Polyus Gold", Priargunsky Industrial Mining and Chemical Union (JSC PIMCU), OJSC "Sayanskchimplast", JSC "Angarskaya Neftekhimicheskaya Kompaniya", JSC "Buryatzoloto", Polymetal International plc, JSC "Irkutskenergo", "En+Group", OJSC "Raspadskaya", CJSC "Rusburmash" and etc.

Due to heavy media coverage of the events, technical professions have become of great interest to university applicants.

The scholarship programs provided by a number of companies have become another motivation for students to study hard acquiring deep knowledge and professional skills: LLC "Rusengineering", JSC "Sibirsko Uralskaya Aluminum Company", JSC "Irkutskkabel", JSC "Irkutskenergo", "BP", "En+Group" and etc.

5. Developing innovative training infrastructure in cooperation with potential employers. Over the last three years, 22 unique laboratories and classes were established at the university due to the assistance of the following companies: OJSC "Sayanskchimplast" (Laboratory of technological process automation); JSC "Angarskaya Neftekhimicheskaya Kompaniya" (Laboratory of petroleum chemistry and organic synthesis, semi-industrial installations for hydromechanical and heat-and-mass processes); JSC "DANFOSS" (Laboratory of asynchronous energy-conservative electric drive); JSC "Irkutskenergo" (Laboratory of complex analysis of power fuel, heat exchange and heat transfer); "Irkutsk Aircraft Plant (branch of IRKUT Corporation)" (computer complex "Technical Operation of Aircraft Equipment"); JSC "TNK-BP" (Laboratory of computer well logging simulation); JSC "SUEK" (Laboratory of numerical rock modeling); JSC "Buryatzoloto" (multimedia room "Underground development of ore and other deposits"); Polymetal International plc (bedded deposit development training room); CJSC "Alrosa", (classroom) and etc. All laboratories are sufficiently equipped with instrumentation and experimental setups. What is more important, the rooms are decorated in compa-

nies' corporate styles, which plays a key role in advertising and promoting companies' interests. The volume of investment in ISTU training facilities exceeded 360 million rubles over the last 5 years.

6. Student involvement in research projects commissioned by high-tech business companies. Quality enhancement of engineering education can be achieved through intensive involvement of students in research projects commissioned by high-tech companies. In 2011, approximately 1000 students pursuing technical degrees were engaged in fulfilling such projects. For example, more than 100 undergraduates and master's students performed scientific work in modern research laboratories equipped with up-to-date facilities and tools in compliance with resolutions of the Government of the Russian Federation № 218 "Development and implementation of a complex of high efficiency technologies in design and manufacture of aircraft MS-21" and "Development of technologies and high effective facilities to produce high-purity spherical quartz grains for electrical component base of the Russian Federation". To implement the project commissioned by Ministry of Industry and Trade of the Russian Federation "Liquidation of arsenic pollution in the industrial area of Angarsk Metallurgical Plant in Svirsk, Irkutsk region" more than 30 students were attracted. There are a lot of examples of this kind when students while studying get engaged in research and industrial experiments, conduct the research based on the obtained results, enter post-graduate program and defend dissertations on time.

7. Application of modern training equipment in teaching and learning process. Over the last three year, 18 modern research-training laboratories have been established to address special needs in such nationally important technological areas as nanotechnologies, aircraft industry and mechanical engineering, power engineering, mining and oil and gas industry, chemical engineering, construction industry and architecture. The centers provide students with possibility to analyze and simulate virtual models of true-life constructions and technological processes revealing technical constraints to their enhancement.

Besides, three new training laboratories designed to support learning process in "Electric Engineering" and "Electronics" have been established within the framework of the projects implemented in compliance with the resolution of the Government of the Russian Federation № 220. These laboratories share the common goals of providing superior training capabilities in the fundamental engineering sciences, which, in its turn, will significantly enhance the quality of our graduates, especially those whose qualification is "Power Engineering and Electronics".

8. Learning through work placement while studying. Beginning in the third year, graduates should take blue-collar jobs, which can contribute to improving the quality of engineering education. For example, the graduates pursuing qualification in "Oil and Gas Well Drilling" are usually interned in petroleum companies to get insight into the field and gain experience in well site construction and drilling, with an average monthly pay being 45 thousand rubles. The students of the Aircraft and Machine Building Industry and Transport work as programmers, designers and engineers in Irkutsk Aircraft Plant beginning in the fourth year. Their course and graduating papers are focused on solving real technical problems they face at workplace. As the same approaches are followed by other institutes and faculties, it is possible to reduce the

adaptation period of our graduates and prompt their career growth.

Besides, each year more than 200 future specialists are involved in development and market promotion of innovative products and services in enterprises of high-tech sector which have been established in compliance with Federal law № 217 and the resolution of Russian Federation № 219.

The discussed types of partnerships for engineering education and business which are rather effectively applied in our university assure high demand in engineers graduated from ISTU. For example, in 2011 demand of engineering companies for our graduates exceeded the supply by 1,54 time, 98 % of students being employed to major industry companies in such sectors as mining and petroleum engineering, civil and power engineering, chemical industry, aircraft and machine building located in Urals Federal District, Siberian and Far-Eastern regions.

The fact that our graduates are found working in the vast territory of the Russian Federation shows that business community is satisfied with quality of their education that can be also proved by the survey results. For example, according to the analysis of the statistics gathered through the survey which was conducted among 300 large-scale Russian companies in 2007 and 2008, ISTU was ranked 11th and 18th correspondingly among the universities of the Siberian and Far Eastern regions [10,11]. Based on the date obtained through the surveys which were conducted among 1100 leading companies by Russian Public Opinion Research Center on commission from Russian public organization "Business Russia", ISTU twice became a member of Russian universities' Alpha League (2007 and 2008).

As the result of the 5th Russian Mining and Exploration Forum "Minex-2009", ISTU was pronounced the winner in the category "Mining University of the Year" among Russian universities for high quality of graduate education in mining engineering. Above all, the student survey conducted by OJSC "Polyus Gold" among 12 universities of Russia in 2011 revealed that ISTU students took the 1st place in the employment rate within manufacturing engineering and the 3d place in mobility potential.

Thus, universities and business will need to cultivate mutually beneficial and lasting relationships with one another in almost all areas of activity to handle the problem of staff shortage, enhance the quality of graduate training and develop effective engineering education system.

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UDC 378.14
(Universal Decimal Classification)

National Doctrine of Advanced Engineering Education of Russia in the Context of New Industrialization: Approaches to Development, Objectives, and Principles

National Research Tomsk Polytechnic University,
Association of Engineering Education of Russia
Yu.P. Pokholkov

The article grounds the necessity and timeliness for the development of the engineering training national doctrine in Russia under the condition of new industrialization, considers potential structure of the national doctrine for the advanced engineering training in Russia, describes the principles of engineering education organization and the approaches to their implementation.

Key words: *doctrine, advanced engineering training, consistency, principles of engineering training management, competitiveness, educational technologies, educational programs.*

Yu.P. Pokholkov

NEW INDUSTRIALIZATION

The word combination "new industrialization" was first used in the pre-election article by V.V. Putin "We need new economy" in terms of necessity to determine the place of Russia in the international system of labor differentiation. The article pointed out that in some development directions of engineering and technology Russia is falling significantly behind the developed countries, though in such directions as space research, military production, atomic industry Russia has accumulated the potential permitting it to remain competitive and occupy its places in the labor differentiation system. Development of traditional for Russia oil and gas branches of industry on the basis of national and foreign technologies allows it to keep its place among the countries defining world policy in this direction. However, in many industrial sectors it should be stated that the level of their development does not only permit to participate competitively on equal terms with advanced countries in the international market but also decreases significantly the opportunity its national production implementation into the inner market. A large number of non-domestic consumer goods embracing all engineering labour, thought and solutions are widely used throughout Russia today. Among which are computers, medical equipment, television, washing machines, refrigerators, automobiles, and motorcycles, products of added-value wood processing, other raw materials, and now airplanes of civil aviation. This list can not only be continued but also added by the list of equipment, supplying the production of capital goods – high-precision tools, molders, rolling mills, welding facilities, integrated assembly lines etc. Analyzing it, one should agree that there are only two strategic ways of industrial development in Russia:

- development of machine, equipment, device production, other consumer's goods produced already in developed countries using foreign technologies, element base and in some cases implementing Russian ideas ("overtaking industrialization");
- development of new technologies, on this basis production of new types of machines, equipment, devices, materials giving opportunity to solve current engineering and technological problems continuously in the condition of changing world, proving formation of new Russian brands in the world market and decent place of the Russian industry in the international system of labor differentiation ("new industrialization", "advanced industrialization").

Without understanding the essence of new industrial policy of Russia one can hardly develop the national doctrine of engineering education in Russia as a basis for formation of personnel potential to realize this policy.

CHALLENGES AND ANSWERS

In recent years Russian engineering education came across the number of challenges of global and national character, among which the most urgent are:

- transition to the training in accordance with the principles of Bologna declaration;
- accession of Russia to WTO, competition in the world market of engineering labor and engineering solutions;
- sharp decrease in status of engineering labor and engineering profession;
- absence of requirements for qualification of specialists in the sphere of engineering and technology, professional standards taking into account the transition to specialists' two-level training;
- market relations with employers;
- contradiction between the former system of engineering training and new requirements to specialists on the part of employers,
- ageing material and personnel bases of universities;
- low number of enterprises provided with modern equipment, permitting for qualitative training of future engineers.

To implement appropriately and timely the above – mentioned challenges into the national education has failed, which, in its turn, has resulted in the crisis within the national engineering education itself, i.e. involving such engineering activity products as projects, technologies, installations, tools, devices, equipment, their operation and maintenance [1]. The scheme presented in Fig. 1, shows the systematic view of the problem situation in engineering and engineering education of Russia.

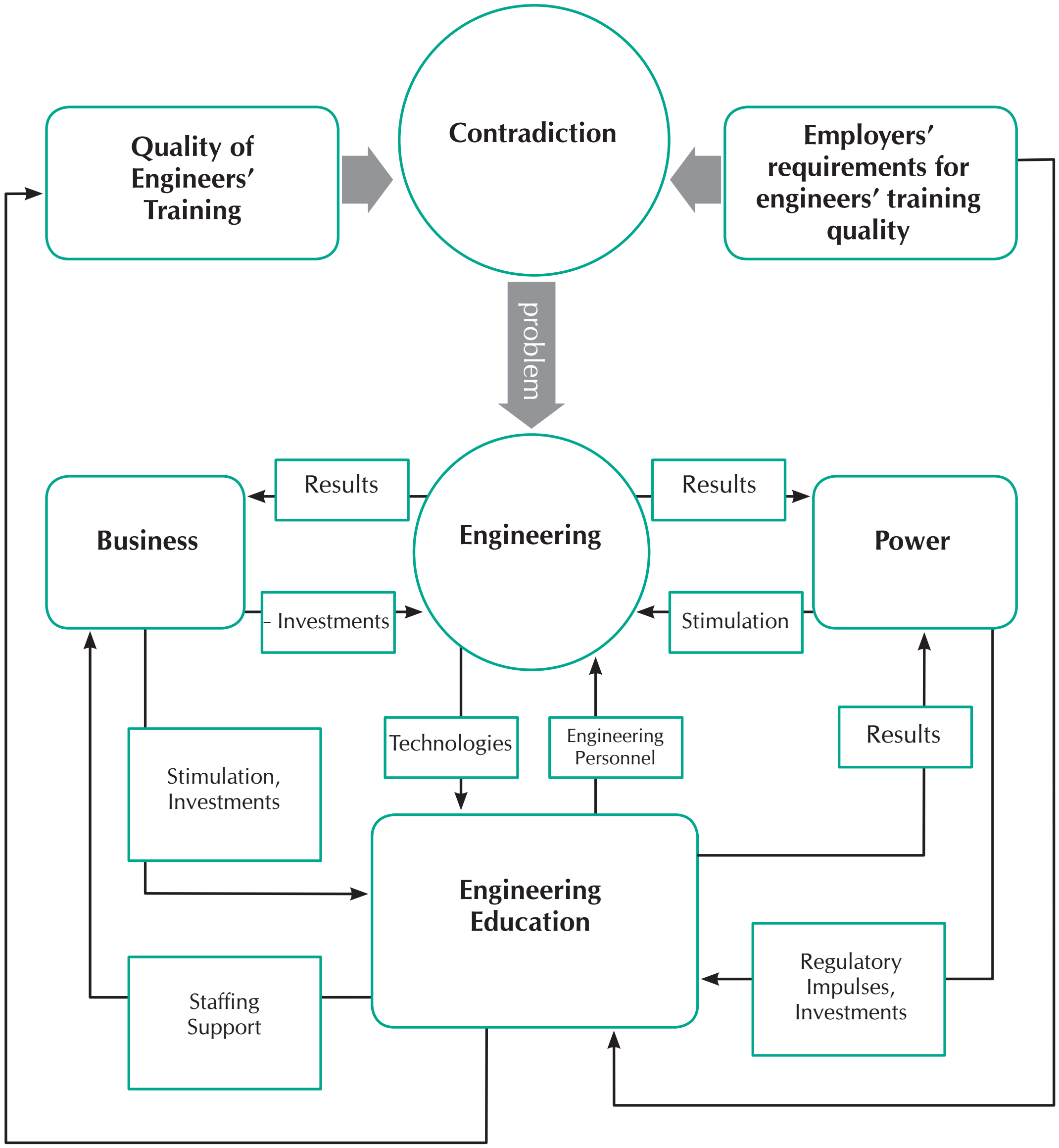
The major part is the contradiction between the quality of engineers' training and employers' requirements. Employers are interested in such specialists' characteristics as:

- ability to think systematically and autonomously and solve the production problems using the competencies developed in university;
- ability to work in a team;
- awareness in business processes and business environment in general;
- ability to generate and adopt innovative ideas;
- ability to present ideas with reasons.

As a rule, the content of engineering educational curricula and educational technologies applied today do not permit future specialists to form these qualities.

Universities arrange their work in such a way that graduates had, first of all, knowledge in subjects studied in university. Doing so, every teacher believes that the more hours he (she) has for teaching, the better he (she) would train a student. Consequently, the assessment criteria of future engineers' training in university are shifted towards the assessment of knowledge.

Figure 1. The Systematic View of the Problem Situation in Engineering and Engineering Education of Russia



In all fairness, it has to be told that in recent years when developing curricula the so called "competence approach" including development of future specialists' necessary competencies is used. However, when the competencies are interpreted as a readiness to show ability in solving this or that production problems, but not a real ability to solve them in real production conditions, employers' expectations are not met. Besides, nowadays bureaucratization of training processes has increased sufficiently when implementing this approach; this resulted in essential increase in volume of teachers' low-efficient, "software" work.

Description of the problem situation in the sphere of engineering training in Russia would not be completed if two periods were not touched in this case – pre-university and after-university.

The pre-university period: today most of parents think that their children are to get higher education in engineering or non-engineering sphere. In this condition reduction of university number in the country and decrease the number of state-funded places in universities is fraught with social outbreaks, all the more so as the situation is added by the complete absence of alternatives for the children who would not enter the universities. The number and the level of technical schools (colleges) do not obviously correspond to the requirements imposed by the current society and business for specialists' training with the initial vocational and secondary vocational education. Even if it is suggested that the state and the number of such institutions can be taken as appropriate, one cannot expect that the opportunity of graduates' employment after such institutions would be high. The state of Russian economy aimed at the development of raw material industries, the level of modern Russian industrial production development does not give any promises that in the nearest future there would be arranged the necessary number of job positions for this category of applicants. One cannot forget the fact that reduction in university number will lead to reduction of teaching staff and search for the jobs for the laid off teachers and lecturers. All this will also contribute to increase in social tension of society.

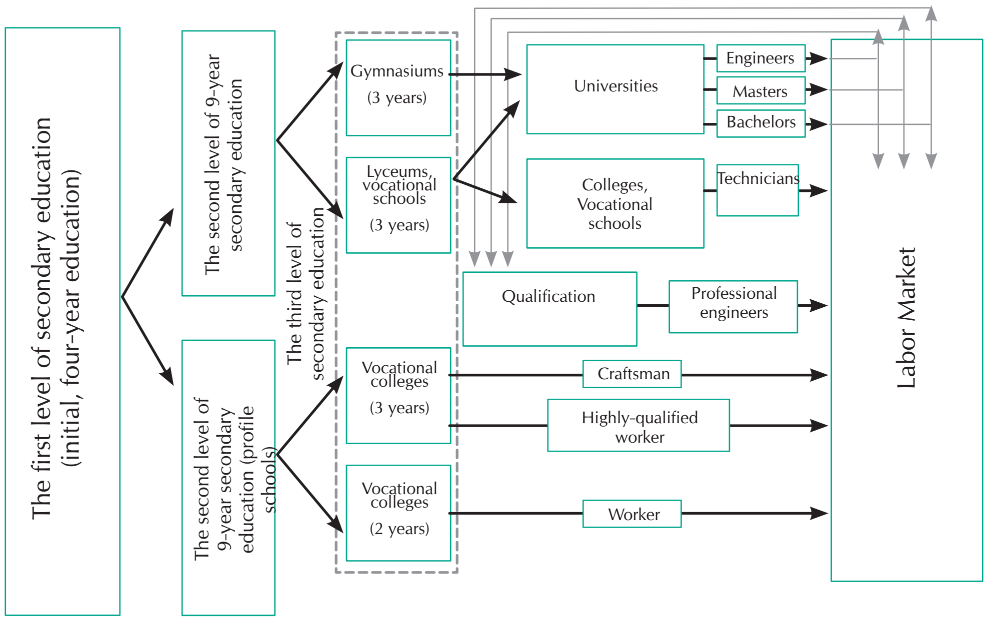
One of the possible alternative ways for solution of this problem is a profound reform of school education including division of pupils' educational trajectories after the 4-th and the 9-th year of study (as in Germany), and arrangement of gymnasiums of Abitur type in Germany, A-Level in Great Britain, Baccalaureat in France. It will require creation of schools of the new type and/or reorganization of lyceum, gymnasium, vocational school, college system. Only those who have finished a gymnasium can enter a university, while graduates of all other educational institutions – only after fulfilling the requirements specified for the gymnasium graduates. Such an approach would permit for supply the labor market with qualified staff: workers, craftsmen, technicians, bachelors, masters, engineers and professional engineers (Fig. 2). Virtually, in this case the number of universities and state-funded places in them may be reduced. It is sure to be taken into account that in doing so the average level of education* and knowledge** of population in Russia would decrease.

The problem situation in the after-university period consists of the risk of disappearance of such a qualification category as "engineer". Transition of universities to bachelors' and masters' training is sure not to imply reduction in the quality of specialists' training in the sphere of technology and engineering. However, in future it will result in absence of specialists having "engineer" qualification who are the key people providing engineering progress and carriers of engineering culture in society.

** The level of education in society can be estimated as the number of years spent for education of one man beginning from seven-year age in average.*

*** The level of knowledge in society (conventionally) can be estimated as a part of population with higher education.*

Fig. 2. The Scheme of Labor Market Supply with Specialists of Engineering Qualifications



Most of those working in engineering universities are quite aware of convention in conferring engineer qualification to university graduates without neither experience nor results of engineering activity by the time of receiving engineer's diploma. It is also well understood by the production workers meeting diplomaed graduates with the following words: "Forget everything that you were taught in the university, we will start to teach you here".

"Engineer" or "professional engineer" qualification, as in most countries in the world, can be conferred to the people with higher engineering education in the sphere of technology and engineering (bachelor, master) as a result of certifying their engineering qualification by professional community. It is provided by engineering certification system in those countries. For examples, in Japan a certificate of professional engineer is given to a specialist graduated from university in Master or Bachelor curricula accredited by public professional organization, having worked in specialty not less than 7 years. He has also to present the documents proving the presence of performed autonomously and implemented engineering solutions, pass two exams on such subjects as "Engineering ethics" and "Ecology" (in the sphere of his engineering activity). A certified specialist is included in the national register of professional engineers [2, 3]. The number of specialists certified as professional engineers to the general number of specialists who wish to get such certificates is not more than 15 per cent. The major part of university graduates trained for technology and engineering sphere work in this sphere in accordance with their qualification (bachelors, masters, specialists) and the basis for engineering corps.

The alternative way of the higher engineering education system development in this condition is not a reduction in university number and state-funded places in them, but organization of large-scale training of specialists for technology and engineering sphere (mostly bachelors) and engineering activity (mostly masters) (Fig. 3). In this case it does not matter whether the general secondary education system will be reformed or it will remain the same. In the

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former case the functions of highly-qualified workers, craftsmen, and technicians will be performed by bachelors prepared for the work in the sphere of technology and engineering.

It is just "training specialists for technology and engineering sphere" is to become the main task for engineering education system of our country.

The group of Masters trained for engineering activity will become a basis for formation of engineering corps, but Bachelor's group trained for technological sphere – the basis for engineering and technological activity for the society.

Bachelor graduates (Bachelors in the sphere of technology and engineering) in addition to professional competencies provided by Bachelor's curriculum are to have skill category in not less than one blue-color job and business competencies. It would allow them to hold the positions of highly-qualified workers, technicians, craftsmen and organize the production in the system of small business. Besides, bachelors may claim for "engineer" or "professional engineer" qualifications under the condition of performing the requirements specified for these qualifications.

Master graduates (masters in the sphere of technology and engineering) in addition to Bachelor's competencies are to have competencies (professional and personal) allowing for successful engineering activity, independent solution of engineering problems, organization of production in the small and medium businesses. This group of master graduates trained for engineering activity and working in chosen profession successfully are the main candidates for award of internationally recognized "professional engineer" qualification. They will form the basis for engineering corps of the country.

MODEL OF ENGINEERING EDUCATION DOCTRINE

Search for the answers for the mentioned questions requires reasonable approach to both situation assessment and choice of development strategy for national engineering education. One of the key tools for this is development of fundamental document presenting "The national doctrine of engineering education in Russia".

Generally speaking the Doctrine presents "A set of officially accepted view points of a definite problem and the means of its solution" [4]. For example, Foreign Affaire Doctrine, Legal Doctrine, Military Doctrine which, by the way, can be "Defense" or "Attack", Educational Doctrine etc.

In any case, a doctrine is an important strategic document having a definite philosophy, on the basis of which the goal is formulated and the ways of its achievements are described in a definite sphere of activity for a long period of time. In modern terms it is possible to be referred to as "a road map".

"National doctrine of engineering education in Russia" is a document where the strategic goal of the native engineering education is set, its role in the economic development of Russia is determined, tools and means of its improvements, methods and main principles of realization are defined on the basis of adequate evaluation of the situation in the sphere of engineering education in Russia and the world.

The importance of the Doctrine development at the given stage of economic development of the country is obvious.

Undoubtedly, the goals of national engineering education development, its role in the economic development of Russia, methods of its improving, tools and means could be different. Their choice and principles of implementation is a subject of thorough analysis and public discussion among the specialists and the society.

The given article presents a definite approach to the organization of engineering education in Russia at the contemporary stage of economic development and has its purpose to conduct "reconnaissance" and, as the saying goes, "draw the fire upon oneself". The argumentative criticism of the statement suggested here for formation of national

Doctrine of engineering education in Russia, new additional suggestions and concepts would permit for finding the optimal ways for efficient development of national engineering education system.

At the end of the 90's "The National Doctrine of engineering education in Russia" was developed and approved by the Government Resolution of the RF №751 of 14.10.2000 [5]. It is a fundamental state document stating the priority (place) of education in the governmental policy, strategy and main directions of its development. Therefore, its principles, structure, and content can serve as a basis for "The National Doctrine of engineering education in Russia" in spite of non-performance of some points.

Approaches to formation of "The National Doctrine of engineering education in Russia" are to take into account global and domestic challenges, trends and tasks of new industrialization, problem situations, their system, possibility of transformation in methods and tools applied for the goal achievement at changing the external conditions. That is the system of engineering education developed in accordance with the Doctrine is to be adaptive.

When defining the long-range goals and tasks of engineering education development in Russia it is reasonable to perform expert evaluation of the required level of the engineering education in the society providing the minimal level of its "innovative resistance" and maximal level of "technologic sensibility".

In the condition of market economy, education and intelligence are the main asset guaranteeing the victory in competition on the world markets as, on the one hand, they allow for production and putting the competitive goods of intellectual labor on the markets, on the other hand, accenting and using efficiently the best current international results of intellectual activity and science-absorbing industry. Defining education as "a public goods" or as "a market goods" is of particular significance in this condition. The principles of education system organization and quality of both every citizen's life and entire society will rely on which of these definitions will be given a preference. At development of the National Doctrine of engineering education and goal setting definite suppositions and hypothesis are to be formulated taking into account of which the models of engineering education structure in our country can be constructed. The most obvious of them are:

1. the world development is based on competition;

2. in struggle (competition) of two cultures and civilizations the culture and civilization of lower level dies or falls in stagnation;

3. the culture and civilization level of society (nation, country, people) is defined by the level of its education;

4. education in society depends to a great extent on the education level of society in general and that of every person, in particular;

5. the level of knowledge and education in society, especially in the sphere of technology and engineering, defines the level of its general and engineering culture, "technologic sensibility", " innovative resistance" and, hence, defines the vector of society development, forms the potential necessary for victory in competition in the world market;

6. a large part of educated population in society is a basis (source) for formation of cultural, scientific, and engineering elite, the activity results of which would permit for breakthroughs in the mentioned spheres and guarantee of victory in competition on the world markets in case of proving appropriate working and living conditions;

7. society with higher level of knowledge and education is considered to be less conflictive, characterized by higher level of general, economic, social, spiritual, engineering, ecological and physical culture, provides decent conditions for life and development of every person.

Acceptance of the mentioned suppositions and hypotheses permits for suggestion of a consistent model of National Doctrine of advanced engineering education in Russia. Realization of such Doctrine model is sure to allow for competitiveness of the Russian engineering developments, goods, and services in the world markets and basis for guarantee of cultural, economic, engineering (hence, military) safety of our country.

The strategic goal in development of engineering education in Russia declared in the National Doctrine of advanced engineering education can be formulated in the following way:

"To design the adaptive system of specialists' advanced training with higher education in the sphere of technology and engineering in Russia, providing the world level in a personal professional qualification, high level of technological sensitivity of society guaranteeing economic, technical, engineering safety of the state".

The organization model of the advanced engineering education in Russia consists of two parts.

The first part of the model that can be conventionally called "Formation of technically educated nation" suggests the organization of the first cycle (Bachelor) of higher education in the sphere of technology and engineering at the expense of state budget. In this case education is rather "a public benefit", but not "a market goods". Implementation of this part of the Doctrine will provide for the high rate of technological society's sensitivity, decrease in the level of its innovation resistance and creation of the basis for the advanced development.

The task of the first part of engineering education organization model in Russia is training of wide population strata in competent and efficient use of ever-changing (complicated) engineering devices, information technologies, software etc. in life and work. The result of this stage implementation in the Engineering Education National Doctrine (increase in technological sensitivity and decrease in innovative resistance) makes possible to hope for acceleration of technical and engineering re-equipment and progress in industry, social sphere and everyday life.

It is supposed that in the course of this stage a man is free in choice of his (her) activity sphere and level of occupied position. The government should not expect from a university graduate (bachelor) to be hired for a job in specialty and for positions corresponding the level of received education, as it does not expect it from the school, college or lyceum leavers. A university graduate has right to choose any suitable for him sphere of activity and may apply, for example, for a position not related to qualification or a worker after university graduation. In this case intelligent potential of the position will be sufficiently higher. A person with higher engineering education is, as a rule, better prepared for application of technical and engineering innovations in the work place of any level that would serve as a guarantee in enhancement and technological development of industry.

People having higher engineering education of even the first level are more prepared for adoption to changing life conditions in comparison with people having initial vocational, secondary or secondary engineering education. They are able not only to find a job, create working places for others, but also, which is more significant in the condition of new industrialization, develop actively small and medium business occupying those niches where victory is more possible in competition of the world market.

The basic conditions for formation of the cohort receiving higher engineering education at this stage must be wishes and abilities of every person. It means that everyone who wishes to get higher engineering education declares his (her) wish applying the necessary documents for the chosen university, but everyone who is enrolled in university in terms of the entrance test is, as a rule, able to receive this education.

It should be repeated that at this stage education is free for everybody, but the expenses are covered by governmental funding of universities compared to university funding in the developed countries.

As a result of implementing the first part of Engineering Education Doctrine, a wide stratum of technically educated population will be formed in Russia; it will present "fertile ground" for growing native scientific and engineering elite and provide favorable conditions for generation and adoption of new engineering solutions and technologies. At the same time, in the course of this stratum formation in the society, the level of engineering culture will be increasing in the society, which is a basis for qualitative project, production, and operation of engineering devices and their safe operation that, in its turn, decrease in anthropogenic and technogenic catastrophes.

From the standpoint of high level of society's engineering sensitivity, the community of people with higher engineering education of the first level (cycle) is to be not less than 40 per cent on average out of the number of people with higher education (Fig. 3). This stratum of population will virtually become the staff ground for new industrialization of the country.

The second part of the advanced engineering education model organization*** that is to be reflected in the National Engineering Education Doctrine in Russia can be referred to as "Formation of research-engineering elite".

In this case engineering education is more likely to be "market goods" the value of which is compensated by the customers the role of which may be performed by government, business enterprise, students themselves, together or individually.

Realization of the second part of the model will make possible to form elite personnel potential for new industrialization of the country, increase the competitiveness of Russian engineering solutions in the world markets sufficiently, provide new Russian brands in the sphere of technology and engineering, and create more favorable conditions for development of the breakthrough technologies.

The goal of the second model part is organization of advanced training (individual or in team) of specialists with higher engineering education (masters, engineers) possessing exclusive professional competencies, capable of generating engineering ideas, take engineering decisions, provide development, production, operation and maintenance of competitive engineering products.

In fact, customers will pay for just specialists' exclusive competencies whose activity results are to provide quick and efficient pay-back of customers' expenses.

Theoretical grounds and practical implementation of the advanced training of elite specialists and professional teams of the world level in the promising trends of technology and engineering were successfully performed in Tomsk Polytechnic University in 2001-2008 that supports the opportunity to organize engineering education in Russia using this scenario [6,7].

The part of people with higher engineering education of the second level (cycle) is to be not less than 5 per cent on average out of the number of people with higher education or 10 per cent out of the number of people with higher engineering education (Fig. 3).

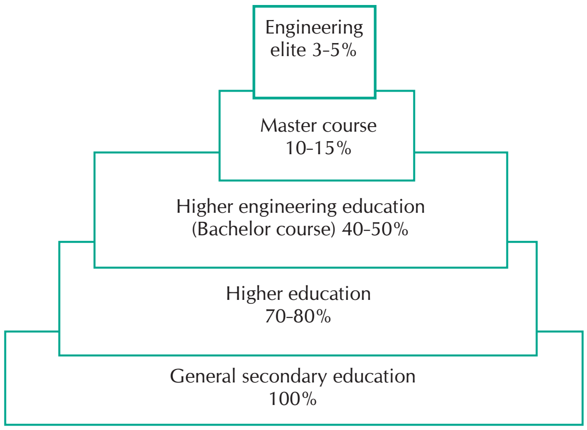
Achievement of the formulated goal for development of engineering education in Russia under the condition of new industrialization will provide putting Russian engineering and technological brands in the world markets and permit Russia to occupy a decent place in the international system of labor differentiation.

PRINCIPLES OF ENGINEERING EDUCATION ORGANIZATION IN RUSSIA

An important element of the Advanced Engineering Education National Doctrine in Russia is principles of engineering education organization the use

*** *By Advanced engineering education is meant higher professional one in the sphere of technology and engineering organized on the basis of progressive research, scientific, research-engineering developments and educational methods allowing for training of highly qualified specialists and teams of professionals possessing exclusive competencies and skills in their application in practical engineering activity efficiently.*

Fig. 3 Specialists' Training for the Sphere of Technology and Engineering



of which would allow for realization of the Doctrine to the fullest extent.

The most important of them are the following:

1. Priority
2. Consistency
3. Fundamental character
4. Advancing principle
5. Practice-focus
6. Continuity
7. Competitiveness
8. Adaptability

The essence of these principles consists in short in the following:

1. Priority principle

Realization of priority principle suggests the governmental policy of priority in taking concrete measures related to engineering education in the country.

In particular, they are:

- development and adoption of the Federal law "On engineering activity in the RF" regulating the requirements for engineering qualification, an engineer's rights and responsibilities, procedure of engineering qualification certification taking into account the best world experience, formation and introduction of internationally recognized national register of professional engineers in the RF;
- inclusion of physics exam in the list of compulsory Unified State Examinations or reorganization of school education including arrangement of gymnasiums finishing of which gives a right to enter a university (like Abitur in Germany, A-Level in Great Britain, or Baccalaureat in France);
- raise in teachers' and lecturers' salary involved in teaching engineering subjects and exact sciences;
- priority in funding the development of engineering university material base, advance training of teaching staff;
- stimulating involvement of experienced native and foreign experts and teachers in the process of specialists' training in the sphere of technology and engineering (including design of educational programs);
- stimulating participation of employers in specialists' training in the sphere of technology and engineering (development of professional standards, curricula, providing equipment, places of students' and teachers' internship, investment in the development of engineering education etc.).

2. Consistency principle

This principle is realized using the system approach in planning measures taken for development and improvement of the advanced engineering education in Russia.

In particular, one should take into account that:

- engineering education is a part (subsystem) of the education system in the country including initial, secondary, vocational secondary, higher professional, extra-qualification for higher education, professional upgrade courses. Any changes in all spheres of public and state activity, changes in peoples' priorities are reflected in the system of higher engineering education;
- engineering education presents itself a system, where quality of engineering training is defined by not only academic, research, innovation activity connected with each other but also depends on a lot of other factors. Such, for example, as a university material base, presence and level of its international cooperation, quality of classrooms, infrastructure, academic buildings ... lavatories;
- when planning higher engineering system and engineering university development, application of consistency principles suggests using management-by-objective method. Implementation of this method is most efficient in case of Development Complex Program development and performance (system, university);
- engineering education programs are to include courses of system techniques and applied system analysis.

3. Fundamental character principle

Application of this principle implies that the basis of future engineers' training consists of fundamental natural science knowledge in accordance with the best traditions of the Russian education that provide:

- high level of future specialists' training in the sphere of fundamental sciences (physics, mathematics, chemistry etc.);
- possibility to use fundamental, basic knowledge for solution of problems in the process of future engineering activity;
- development of mental abilities, system, abstract and analogue thinking;
- development of analytic and synthetic abilities, abilities of attention focusing and mental potential in solution of theoretical and applied problems in different spheres of technology and engineering and taking adequate action in different conditions (for example, in exam session, non-standard and extreme situations).

The necessary conditions for this principle realization are:

- high level of research performed at profiled departments;
- active participation of academic science representatives in training process;
- students' active participation in scientific research.

4. Advancing principle

The given principle suggests:

- inclusion of courses, the content of which represents the latest achievements in the given sphere of technology and engineering, in the curriculum that would provide advanced knowledge;
- design of curricula (content + educational methods) performance of which would permit future specialists to form not only standard but also exclusive competencies providing high level of being in demand in the professional sphere and successful career;
- arrangement of elite engineering education in universities that allows for selection and training of most gifted, talented and motivated students in the advanced curricula for the further engineering and research activity;
- organization of university "centers of excellence" focused on the performance of perspective researches,

students' elite training and workers' upgrade courses.

5. Practice-focus principle

Performance of the principle suggests:

- application of practice-focused educational methods based on techniques of problem-oriented and project training as well as block-modular structure of a curriculum;
- using method of team training;
- sufficient increase in share of students' self-study in the common volume of curriculum including performance of real tasks and projects in the chosen sphere of technology and engineering forming skills of detecting problems and finding ways of their solutions;
- obligatory inclusion of courses or parts of courses providing formation of future specialists' skills to solve non-standard engineering problems (for example, TIPS etc.) and public defense of engineering solutions;
- employers' participation in training that can be expressed in both invitation of experts in training process (discussions of problem situations) and arrangement of practice for the future specialists in the advanced native and foreign plants;
- changes in training process design including teaching load distribution in departments and formation of staff timetable not in terms of academic hours but the number of students;
- training process arrangement (especially in masters' and engineers' training) in terms of block-modular curricula giving possibility to reduce the period of a graduate's adaptation for production conditions.

6. Continuity principle

Performance of the continuity principle suggests:

- formation of future specialists' demand for consistent, systematic upgrading of the competencies developed in the training process;
- development of continuous system of re-training and upgrading in all profiles of specialists' training in the sphere of technology and engineering;
- development of network of problem analysis centers in the sphere of technology and engineering to form and operate (upgrade) the database of engineering problems;
- arrangement of engineering business center network (business activity in engineering), providing formation of conditions for development of people's business and creative initiative, working in different spheres of technology and engineering;
- formation of conditions (stimulation) for wide publicity of engineering activity results and development of engineering skills in children and adults in mass media.

7. Competitiveness principle

Development of competitiveness for native engineering education, increase in the share of Russia in the world education market is one of the key tasks, decision of which is be foreseen in the National Doctrine of the Advanced Engineering Education in Russia.

Performance of competitiveness principle suggests:

- development and design of engineering educational programs on the basis of best experience in design and performance of similar educational programs of leading and well-known universities in Russia and world (presumably, with participation of leading foreign experts) and the best traditions of the Russian education;
- formation and advertising of the best traditions of Russian education in the international mass media;
- formation of conditions (stimulation) for active participation of Russian universities in the international exhibitions, fairs and other events;

- internationalization of higher engineering education, development of academic mobility;
- formation of conditions necessary for foreign students' training in the universities training specialists for engineering activity (language environment, teaching staff, research conditions, quality of classrooms, domestic conditions...);
- arrangement of qualitative specialists' training university centers.

8. Adaptability principle

As it was mentioned above, engineering education is a subsystem of the world and Russian educational system, in particular, the systems of social, cultural, economic sphere in general. Hence, all changes in these systems and spheres result in new challenges in the system of engineering education. Appropriate and timely replies to these challenges would provide the efficient functioning of higher engineering education system, its international competitiveness. In other words, engineering education system is the ability to adapt to the changing conditions of the environment. This criterion is the continuous demand of the specialists with Russian higher engineering education in the domestic and world spheres of engineering activity.

Performance of adaptability principle suggests:

- arrangement of special analytical centers (of the federal, regional, and university levels) for continuous analysis of environment challenges to the system of engineering specialists' training and development of recommendations for the higher engineering education system adaptation to the changing conditions;
- development and efficient operation of international and native system of professional certification in engineering educational program;
- using the results of certification for educational program improvement and their adoption to the new requirements;
- arrangement of university feedback with the graduates to manage the quality of specialists' training with minimal delay period.

CONCLUSION

Development of the National Doctrine of Engineering Education in Russia is a complex and time-consuming process. In formation of this important document a number of factors and conditions are to be taken into consideration, a plenty of activity spheres are to be involved (schools, colleges, vocational schools, Russian Academy of Education, Russian Academy of Science, business, mass media, educational technologies, education content, university teaching staff formation, students' stimulation etc.).

The central figures in this process are to be Russian experts and professionals in the sphere of organization and performance of higher engineering education. Selection of these experts is also rather a hard business. The practice of tendering process is not appropriate in this case. The Doctrine is a state document and its executive is to become a state institution responsible before the President and Government. In the given case it is the Ministry of Education and Science of the Russian Federation. The scenarios of such process organization can be different from performance of this job by experienced and highly qualified workers of Ministry to arrangement of some independent expert teams by the Ministry working simultaneously at the project of this document. Then the suggest versions of the Doctrine are to be discussed by public and professionals and undergone an independent examination under Ministry guidance. A more appropriate variant of the Doctrine as advised by the RF Ministry of Education and Science is approved by the RF Government and becomes a document defining the future of engineering education in Russia over a long period.

ENGINEERING
EDUCATION
10'2012

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UDC 378.662:330.342.23
(Universal Decimal Classification)

Industrialization as a major driver of engineering education transformation. Engineering education: a course for new industrialization

Tomsk Polytechnic University
P.S. Chubik, M.P. Chubik

The article deals with key mechanisms of native engineering training system modernization in the context of new industrialization course declared by the Russian Government and main tendencies of modern native and world engineering education development.

P.S. Chubik

M.P. Chubik

Key words: *new industrialization, engineering education, professional skills of engineers, globalization of higher education, transdisciplinary university of XXI century.*

Making report at the beginning of the autumn of 2011 in Cherepovets Vladimir Putin told about his visit to one of near-Moscow schools where he read the statement in a social science textbook about the fact that in the 21-st century in comparison with the previous one "the center stage is taken by the service sphere, but production sphere is yielding to it".

"It is a very controversial point, very controversial. Now we can see that some countries, which have got carried away for deindustrialization, are reaping hard, bitter fruits. Following the production they are losing engineering centers, brains are draining, and this makes the condition for degradation. Therefore, it is too early to speak that industrialization has died. We need industrialization on a new base. It is true", – the Chairman of the Government commented the statement [1].

At the end of 2011 at meeting of All-Russia public organization "Business Russia", a candidate for President of the country Vladimir Putin lifted the veil over the new industrialization project advertised by him before [2]. According to his version, to change the structure of economy one needs to modernize or organize some million of high-tech working places.

In April 2012 the elected President being in the position of the Chairman of the Government reported to the State Duma about his work. Presenting the plans for the future he stated the development of modern components of production process as a strategic task for the nearest years noticing that the world has entered the epoch of turbulence and a new wave of technological changes is coming [3].

7, May, 2012 being already President of Russia Vladimir Putin signed 13 Decrees including the decree setting a new industrial project – creation of 25 million of modern high-tech working places by 2020.

This industrial project will become the third one in the history of our country.

The first "empire" industrialization was started by introducing the policy of protectionism in 1822. Due to high custom tariffs and defense of internal market from foreign competition in the Russian empire the competitive cotton, textile and sugar manufacturing industries were established. Machinery production appeared. A serious engineering reconstruction of metallurgy was performed. The railway boom took place.

The second "social" industrialization started after the adoption of the first five-year plan of national economy development at the XV Congress of All-Union Communist Party (of Bolsheviks). By the end of the second five-year period the Soviet Union took the second place in the volume of industrial production in the world yielding only to the USA. In the 1930's the growth of industrial production amounted in average 15-18 % per year. The accelerated industrialization permitted the USSR to achieve economic independence from the West in the strategic production. Within the period of two five-year periods, new fields of industry were created: building, aviation, automobile, tractor-manufacturing, chemical etc.

Both industrial waves were accompanied by drastic reforming in the native system of engineering education [4, 5, 6].

In Russia higher engineering education itself appeared almost simultaneously with the first industrial breakthrough. In 1810 the school of engineering corporals (busmen) training was reorganized in engineering college with two departments. Busmen department offered three-year-course for training junior officers of engineering corps, engineering department offered two-year-course for officers of engineering profile. The best graduates of Busmen Department were enrolled in Officer Department. After introduction of additional training stage in the Engineering college that was named Main Engineering College the systematic approach to establishment of Russian higher engineering school appropriate for current challenges was formed.

The network of schools was gradually extended: in 1828 the Technological Institute was established, in 1830 — Architectural College, and in 1832 — College of Civil Engineers. Besides, technological institutes were established in Kharkov and Riga, as well as Imperial Engineering College (now – MSTU named after N.E. Bauman). In 1900 at the end of the 19-th century Tomsk Technological Institute of Emperor Nikolay II was established, a first native engineering university on the vast territory of the Asian part of Russia.

Finish of building Transsibir trunk line provoked rapid growth of economic development in Siberia. The new industrial development vector required greater number of engineers. That is why old engineering institutions extended as quickly as possible, but it was not enough, therefore new ones were established. New institutions were of polytechnic type and had a four-year curriculum. Large polytechnic institutes were established in Kiev and Warsaw, Sankt-Petersburg and Novocherkassk.

Engineer's job was gradually becoming very popular and the number of young men wishing to get it was several times more than the number of vacancies. In 1913 the average income of industrial engineer was 10 times more than the average salary of a low-qualified worker and 2-3 times – that of qualified one (a turner, a fitter, a master etc.). The majority of engineering institutions applied competitive entrance examination for students' selection. The prestige of a professor in engineering institutions was very high and best talented men competed for the right to occupy the vacant positions in teaching staff.

In the period of Nikolay's II rule there appeared some new challenges. Now engineering specialists were in demand by not only state organizations and institutions but also large and small business enterprises of the developing industries (electrical engineering, oil refining and chemical industry, machinery, metal and wood industry, raw materials, etc.), as well as autonomous bodies. Therefore, the Tsar government paid special attention to extending and enhancing the quality of engineering education at the turn of the 19-20-th century. It appeared to be forward-looking enough to estimate the current perspectives of global scientific-engineering development in time and take measures, without which our country would not stand neither in the First nor in the Second World Wars and keep its status of the world power gained in the 19-th century. The public position of the Russian engineering institutes being under the personal auspice of emperors and highest officials was unique in Europe. According to P.N. Ignatiev's evidence, a Minister of Education, Nikolay II paid greater attention to the development of just engineering education and some institutions (first of all, Warsaw and Tomsk Technological Institutes) were under his personal auspice. Undoubtedly, this circumstance is one of the reasons for fantastic economic and infrastructure leap forward at the turn of the centuries. As a result, by the beginning of the First World War the Russian system of higher engineering education could be compared with leading European systems in relative scales (with respect to the number of population).

The research of recent years has shown that the basis for success of such native high-tech industries as power engineering, machinery, chemical, electrical engineering, optical, aviation, ship-building, defense industries were founded not after the Revolution, but in the last two pre-revolutionary decades [5]. The USSR inherited from the Russian Empire strong and balanced, well funded system of engineering education.

Developing the Russian engineering education and science Peter I laid the foundation in the form of classical triad "gymnasium – academic university – scientific academy", which is based on the principle of governmental support under the condition of applied use. That principle remained unchangeable in the period of educational reforms of Ekaterina II and Alexander II as well as in the period of initial industrialization. It was not virtually changed even in the period of the social industrial breakthrough. In contrast to juridical and historical-philological, engineering education was preserved and continued to develop. After the ruin of the Tsar Empire it was successfully adopted to the needs of the Soviet planning economy through a number of reforms.

A new element in the educational system introduced by the Soviet power was the principle of egalitarian education, i.e. education for everybody that, in particular, meant enormous work in creation and enhancement of education and the system of research institutions in the regions, not only in the capitals.

Engineering in the USSR became more female. Soviet higher engineering institutions enrolled women without formal limitations and by the mid of the 50's of the 20-th century women made up one third of the engineering students, but among working engineers they amounted 28 %.

The Soviet achievement was increase in potential of the Academy of Science by means of establishment of research institutes as a first section of research organizational structure. In the period of Revolution all degrees were annihilated, but in 1930 they were restored (two degrees were approved: Candidate and Doctor of Science). Development of Soviet natural science and engineering can be characterized as a rise. The developed network of fundamental and applied branch research institutes, construction bureaus, and university laboratories covered the entire range of research. A lot of new technologies were designed. For example, only during the first five-year period the production of synthetic rubber, motorcycles, watches, cameras, excavators, high quality cement and steel was set up. On the developed industrial base it became possible to reweapon the army.

In the 30's the system of engineering education was forming and developing that permitted the USSR to come from the Agricultural Epoch to the Industrial one and became one of the leading countries in the world. Adoption of the first five-year plan and start of the second industrialization initiated the university reform of 1930, when in terms of the Decree of Supreme Council of National Economy of the USSR old institutes were disembodied, but on the basis of their departments, faculties and research schools numerous branch institutions were established that were under the authority of People's Commissariat for Economy and trained in large-scale narrow focused specialists in short-period curriculum. Thus, Tomsk Technological Institute by that time renamed in Siberian Technological Institute was divided into five institutes, three of which stayed in Tomsk (Siberian Mechanic-Machinery Institute, Siberian Chemical Engineering Institute and Tomsk Electromechanical Institute of Railway Engineers), Siberian Building Institute was moved to Novosibirsk, Siberian Metallurgical Institute – to Novokuznetsk.

The main task of the first five-year plan of higher and secondary education development was to increase specialists' graduation, first of all, in engineering speciaities, under the condition of their training quality improvement [7, 8]. The life of country economy according to five-year plans gave possibility to know the required number of engineers in every qualification beforehand. Under these circumstancese introduction of narrow specialization in engineers' training had definite advantages. For such a specialization institutes of polytechnic type were especially suitable, that served as a main reason for their division into separate institutes. Each of these institutes was established for training specialists in a definite branch of industry and, therefore, assigned to a definite governmental structure. Increase in the number of diploma engineers was achieved owing to "optimization" of the training process. Non-majors were taken away from the curricula, in some engineering universities the period of training was shortened to 3-4 years.

However, in the course of time the drawbacks of such training became obvious, and most of institutes, institutes with older traditions in particular, avoided narrow specialization and returned to curricula similar to those before the Revolution. The government offered People's Commissariats to review the list of qualifications which were trained in universities to reduce the list of specialities to the maximum and to approve them taking into account the development perspectives of the given economic branch and science and engineering achievements as well as the necessity to give a professional a wide general-science and general-engineering training for the profound acquirement of the speciality. Due to this Decree there was a wide discussion on the questions of profiles being arranged in the country. As a result instead of 950 specialities existed by the mid of 1935, only 275 wider specialities were included in the list.

In 1932 the Soviet of the People's Commissariats adopted a special Decree according to which the share of practical classes and production internship not less than 30-40 % of academic time are to be devoted in higher and secondary institutions of engineering profiles. For this purpose every engineering university was assigned to this or that enterprise, and students were obliged to submit individual reports on production internship, these reports were to be estimated at the examination.

The labor of university teachers was better stimulated, their salary increased. If in the 1920's a professor's salary amounted only 50 % of an industrial worker's salary, already in several years after launching the second industrial project, a professor's month salary was approximately ten times more than that of a worker. Extra pays were introduced again for scientific degrees and titles as well as the number of post-graduates increased (from one thousand in 1928 to 16,8 thous. – in 1940 and half of them was specialized in engineering fields). As a result, by the beginning of the War the native system of engineering education could train engineers ready for involvement in production process just after getting university diplomas.

Profession of an engineer became popular again and engineering institutions drew attention of the best pupils. The number of university students increased 2,8 times within the first five years. Particularly impressive was the growth of the number in engineering workers at machine-tool and metal-processing plants: from 28 th. in 1928 to 253 th. in 1937. Within the period from 1930 to the 1940's the number of engineering universities in the USSR increased 4 times and exceeded one and a half hundred. One can state that before the beginning of the Great Patriotic War the Soviet engineering school was formed and it was this fact that helped our country to rearrange economy for military needs quickly and then restore in the nearest year after the war in spite of all destructions.

At the same time, intensive socialist industrialization together with large-scale involvement in engineering education changed significantly the professional image. Liquidation of market economy and concentration of high-tech technologies in state enterprises exclusively resulted in regression of a number of engineering competencies (in particular, "economic" and "managerial"). In contrast to engineers of Tsar Russia characterized by great learning and good knowledge of European languages, Soviet engineers, as a rule, were narrow-focused specialists not almost speaking foreign languages. In the Post-Soviet period reduction in engineering competence range worsened even more. However, steady trend for engineering specialization, concentration of high-techs in large corporations, transformation of engineer into mass profession took place in the Western countries as well.

Industrialization and engineering education are interconnected processes. Industrial waves always revolutionize the system of engineering staff training. The first native industrialization formed a unique model of Russian engineering education and led to development of engineering institution network. As a result of the second "socialist" wave engineering profession became mass that, to tell the truth, resulted in some regular simplification and even dilution of engineering profession essence. In this period optimization of engineering university complex was carried out, the nomenclature of qualifications was put in order; unification of training process was provided. Developed in the course of two industrial projects the system of Russian and then Soviet engineering education was efficient enough, that was demonstrated by widely recognized achievements of the USSR in science and engineering.

It is indicative that both industrial waves, Tsar and Soviet, had a number of common features:

- development of higher engineering institutions network quantitatively and qualitatively;
- increase in state investments into material base of engineering educational institutions multiply;
- active popularization of engineering and engineering staff training process;
- enrollment of the best school-leavers and raise of competition for engineering qualifications;
- growth of prestige and status of both engineer as a profession and a teacher in a higher engineering institution, simultaneous increase in their salary and wealth rate;
- sharp increase in the number of students in engineering universities, growth of post-graduates' and teachers' number;
- establishment of new qualifications and profiles in higher engineering education, putting in order the current nomenclature of specialities;
- raise in importance of research component of engineering staff training process, promotion of wide and general engineering training;
- actualization of production internship, direct contacts with economic production sector;
- high attention and interest to higher engineering institutions from the government.

But what conceptually new features should engineering education system gain for the third wave of industrialization?

The first new feature is interdisciplinary and transdisciplinary education accepted in Anglo-Saxon educational model according to which it is considered to be appropriate for a student to unite a course on material engineering and nuclear physics with evolutionary microbiology and marketing. In the leading foreign universities students' training and scientific research are, as a rule, performed in engineering, natural, social, humanitarian sciences and science about life (including medicine) taken together. Hence, interdisciplinarity, promoting today development of all breakthrough technologies, in foreign universities starts straight from student's years. Presumably, today we buy high-tech medical equipment mostly in the Western countries, because its development is started by the students – future doctors, engineers, physicists studying in the same university, living in the same hostel, spending time at the same parties.

Universities occupying steadily the leading positions in prestigious international ratings (ARWU, THE, QS World University Rankings, Webometrics,) – Cambridge, Harvard, Yale universities perform students' training in all basic profiles: social and humanitarian sciences, mathematics and natural sciences, medical and engineering sciences. Even Massachusetts Institute of Technology, the most prestigious engineering university in the world, has departments of biology, humanities, health protection, and management in its structures. Narrow "branch" specialization of the native universities resulting from socialist wave of industrialization, in the course of which appeared new industrial branches from the ground up is one of the key reasons for retardation of Russian higher educational institutions in both international ratings and in the volume and quality of scientific research.

Today in the world there is a tendency of gradual diffusion of boundaries among disciplines and qualifications, and every serious research makes a modern scientist use methods of "related disciplines" and place the object of research in other scientific dimension. Therefore, an engineer of new generation is to be a synthetic specialist as well. The fact is that in real life, especially in small high-tech companies that are the main generator of innovation in modern economy, an engineer turns out to be a researcher, an analyst, a consultant in a wide range of topics, and a manager simultaneously.

Quite recently, Yefim Pivovar, rector of Russian State Humanitarian University, a leading national humanitarian university, declared that there won't be "pure" humanitarians soon [8], as convergence among the sciences is of more significance. In this case symbiosis of sciences is possible, quite different and far from each other. Association and enlargement of universities in Russia is necessary and inevitable, thinks Vladimir Vasiliev, rector of Saint-Petersburg National Research University of Information, Technologies, Mechanics and Optics. In his words, universities in, for example, Petersburg were established, basically, in the 1930's and were focused on one or another branch of industry and economy. Today the development of higher school is performed on the basis of definite interdisciplinary crossing that will intensify in time.

"Russia even delayed a little with the process of enlargement and association of universities, as this tendency has been obvious over the whole world long ago beginning from the USA and finishing with China", – noticed Vasiliev [9].

Andrey Fursenko, speaking at the Forum "Russia and the world: 2012-2020" [10], called not to oppose engineering and humanitarian education. In his opinion, in the sphere of education and science development it is necessary to transcend the technocratic scenario consistently, avoid branch division for knowledge convergence, as nowadays the most interesting researches are not divided in trends: for example, nano-bio-information-cognitive techniques are impossible to refer to natural or humanitarian sphere unambiguously. Skills in arguing, formulating one's thoughts beyond the common convictions are the main results of modern convergent education having interdisciplinary and super-disciplinary character, equally urgent for both future historian and future physicist.

Thus, we need "large" universities of new type. They are possible to be established in several ways. By means of uniting and enlargement as it was made in establishing most of federal universities or by arranging consortiums in which every university is legally independent. But for this purpose it is necessary to change the current legislation (curiously that a number of departments of MSU are legal units).

The bright example is Sorbonne that, in fact, gained its modern organization not as a result of mergering, but, vice verse, division [11].

In 1972 Sorbonne or University of Paris, after famous students' revolts of 1968, was divided into 13 autonomous universities, differentiating in profiles of training. Some of these universities are located in the historical buildings of Sorbonne, the rest – in other blocks of Paris and its suburbs.

At the same time all universities have a single infrastructure (for instance, Interuniversity library) and common administrative and academic units – Practical School of Higher Education, Paris University Office, and Academic University Administration. In addition, they are connected as a unified whole by a network of organizations and institutions of general assignment – such as Upgrading Professional Center, Occupational Guidance Center, Interuniversity Sport Center. Besides, each of these universities performs some function for common benefit. For example, at Descartes University there is interuniversity service of prophylactic medicine and health protection; at Paris-Sorbonne University there functions a Unified center of Documentation and Radio station; at New Sorbonne University – Culture center and Press-Agency.

New convergent universities are a necessary condition for interdisciplinarity. They give a student possibility to complete a course of system analysis at natural science department, a course of social engineering and resource efficiency at humanity department, engineering entrepreneurship – at economic department etc. in the process of study.

In fact, there is another way of interdisciplinary arrangement i.e. academic mobility, but domestic higher school is not ready for this in large-scale yet. Numerous administrative barriers, need in additional funds, underdeveloped transport infrastructure, price imbalance in rental property market – all these limits students' and teachers' mobility significantly. A European student can easily move from one country to another, without any loss, study there half of a year and get back. In our country it is often required to retake exams and re-credit when changing university, in this case universities can belong to different authorities that makes the procedure even more complicated.

One more new feature of Russian engineering education is connected with its inevitable globalization in both national and international aspect.

What is it conditioned by? Within the country – by the announced program of organizing 25 (!) million of new high-tech working places. In the external aspect – by globalization of the world economy and WTO accession. External factor implies inevitable harmonization of the native engineering training model to the world best one.

What changes will it require? Significant.

In this case the role of school training system and unified state examination (USE) is to be reoriented, first of all, to the new wave of industrialization. Obligatory exams for all school leavers, apart from mathematics and Russian, are to be physics, chemistry, biology, social science and foreign language. It is a key problem forming the basis for algorithm of vocational training of new generation and requires an urgent solution. With present approach, when USE in physics is passed by only 25-30 % of school leavers and, doing so, competition in engineering profiles is potentially 3-4 times lower than in the other ones. To organize a new industrialization wave is hard, even under the condition that of "25 million" future university graduates will constitute only a part. The road to higher engineering education should be wider. However, taking into account all mentioned above, any routs are to lead a school leaver to a unified sub-disciplinary "Rome" all the same.

The additional mechanism, promoting the transition from accepted narrow-focused educational paradigm to convergent transdisciplinary university of the 21-st century, can be development of wide network of lyceums-boarding schools at leading universities of the country strictly regulated by federal and regional programs of youth support in Russia.

The necessary final condition for preparation of launch platform of the third Russian industrial wave is to become total striving of potential entrants to choose just engineering qualifications. How to do it? Inserting Russian higher educational institutions into the international system of curricula accreditation and professional engineers' certification.

Certified professional engineers entered in definite national registers are, in fact, engineering elite for industrial companies and state in general. It is they who drive economy in the way of innovations and provide its competitiveness. What does the presence of definite number of specialists of international level entered in corresponding registers get to a company? A possibility to participate in international tenders for technical and engineering works. What does the presence of such companies give to the country? Involvement in the global economy as a full value partner, but not " an assembly plant of foreign machines with foreign parts". What does a record in the international register get for an engineer? First of all, free choice – in life style, task complexity, country to live in, and income rate. The companies interested in hiring certified specialist have to pay salary "at the level of international standards". Isn't it the dream of any entrant who gives the results of his USE to the university admission office?

On such a modernized "skeleton" of basic conditions one can build up a package of recipes for intensive therapy of engineering education sounded many times both in our country and abroad [12, 13, 14]:

- renewal of mechanisms for wide youth's involvement in creative process – revival of existing in the Soviet period branched system of youth's vocational training (including numerous schools and clubs of research-engineering creative work etc.);
- extension of engineering competencies including multi-level extra vocational education for engineers wishing to get entrepreneur competencies (a reversed scheme is also possible – a businessman with economic background can get basic engineering skill through the system of appropriate extra training);
- upgrading of engineering education content, introduction of modern pedagogical techniques (project- and problem-oriented training), enhancement of academic mobility programs, post-graduate course upgrading, improvement of cognitive educational techniques, students' focusing at practical implementation of final projects; reasonable combination of traditional teaching methods with innovative ones.

Finance question is of importance too: increasing job prestige one cannot do without essential raise of average salary for this job. Industrialization and transfer to new innovative economy are impossible without critical amount of people capable of designing, managing and supporting modern resource-efficient technical processes. Today there are slightly more engineers and designers of all fields than guards and less than service workers of hotels and restaurants [14].

The complex problems are solved by only a set of measures, but not partial actions at separate sites. To raise the prestige of a technician one should pool the interests: general-education school, higher school, business and government. Otherwise, there will not be those who would perform industrialization in the post-industrial world.

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UDC 378.016
(Universal Decimal Classification)

Approaches in Designing the National Engineering Education Doctrine

Siberian Federal University
S.A. Podlesniy

Aspects in designing the national doctrine of advanced continuous engineering education under conditions of today's Russian industrialization and globalization within the economy sector and education space have been considered in this paper.

Key words: *engineering education, national doctrine, postindustrial society, public policy, private and state partnership.*

S.A. Podlesniy

The development and implementation of the national engineering education doctrine (herein referred to as "Doctrine") is a crucial problem determined by numerous factors. One factor embraces the role of the engineering education in procuring stable civilization development, XXI-century global problem-solving aspects (world-wide natural resources depletion, environmental degradation due to increasingly large-scale human activity impact, energy crisis, etc.), implementing adopted Government Strategies of Innovation Development in RF (2012-2020) and multi-national security problem-solving aspects. Another factor involves the circumstances and problems associated with engineering education and engineering itself in Russia. According to various estimates, the system of human resources (HR) training in technology and engineering has been facing critical and serious problems [1].

A national-level perspective document, explicitly stating the major challenging objectives and tasks and functions of the state, business, higher education institutions and R&D institutes, should be adopted to reflect those integral views of the existing research-and-technology community, society, government, businesses and individuals, which, in its turn, would further the development of the national-technological base, innovative economy and engineering education [2]. Such a document should incorporate a system model of the multi-level advanced continuous engineering education within the post-industrial -information community, as well as, interrelate the national and market mechanism regulations. This Doctrine should include the best of domestic and foreign experience and knowledge. The implementation of the Doctrine shapes the background to provide a stable country development, to update the industrialized and national security sectors and to rate up the global market competitiveness of Russia in high-technology and education services.

The Doctrine is the key national document emplacing the engineering education into state politics, determining its strategies and basic development areas during the transition period to the stable development and shaping of the post-industrial community and globalization of economy and private-public partnership. The following document should determine the long-term strategic objectives and tasks of engineering education, their performance model, necessary resources, stages, implementation mechanisms and expected results.

The development of domestic engineering education and its global quality improvement is a rather challenging systematic problem, involving political, legislative, economic and management activities, as well as, supporting research-technology activities, precise public and business strategies and tactics. Doctrine design is based on the systematic analysis of modern day-to-day realities in the research-technologic and socio-economic spheres of the post-industrial community and Foresight-technology within the forecoming 15-30 years. The following issues are highlighted within the framework of the Doctrine itself: integration of Russian engineering education system into the global education space; conditions providing its promotion, continuity, integrity and fundamentality; future-oriented requirements to engineers; training content; educational technology and high-quality engineering training.

Outlining the different approaches in developing the Doctrine, the positive and negative factors revealed during the implementation of the adopted Government resolution" RF National Education Doctrine" in 2000 should be considered.

Engineering education dominates the leading positions in the system of higher professional education and includes the following characteristic features:

- far-reaching sub-system of higher professional education;
- high-technology education sphere;
- direct influence on the country's technological development, its dynamic innovation progress and global competitiveness;
- multi-aspect curriculum disciplines requiring prompt content updating;
- significant academic improvement relevant to the engineering status, research and R&D project financing and effective professional engagement and interaction with strategic partners;
- significant financial costs in developing research university laboratories and physical infrastructure;
- requiring exclusive physico-mathematical competence of school graduates and their profession orientation.

Major problem-solving aspects in engineering education:

- no clear-cut long-term development- strategy of the engineering education system itself, undefined ideological basis and interested partners;
- no integrated system of forecasting and framing requirements for engineers, based on labour market analysis and technological development [3];
- no industrial policy;
- significant severance of close-up ties between science, education, industry and business affecting the motivated content and quality-level of specialist training;
- no uniform professional standards in most industrial sectors; in many cases a mismatch between the university infrastructure itself and existing accepted requirements, distressed equipment in student learning and shortage of hardware and software packages;
- underdeveloped institutional science and inadequate development of innovative-oriented intellectual marketable products (patents, licenses, etc.) for real economy;
- deep-in problems in organizing on-the-job training (internship);

- inadequate promotion of academic mobility (student exchange) programs;
- financial budgeting of Russian higher education institutions significantly lower than that of universities in highly-developed countries;
- low export provision of educational services abroad;
- imperfection of the legislative framework, discentives and no preferences leading to disinterested businesses in co-financing engineering education;
- ageing of faculty, low salary level inconsistent to faculty qualification and experience input resulting in low-rate recruitment of young professionals;
- unappealing scholarships for engineer-students;
- lowly- occupations such as engineers, instructors and research associates due to existing realities within Russia;
- physico-mathematical competence of school graduates significantly decreasing;
- system failure of professional orientation (career guidance) education of school graduates in technology and engineering.

Basic priorities and socio-economic characteristics of the post-industrial community are quite different from those of the industrial community. One difference is the principle of sustainable development and the shaping of a new behaviour model, both of which, embrace the education sphere. The predominate new economic industry type is the production of customer-order goods and services. The production management principles are changing- multi-national corporations and virtual enterprises have emerged, which have no fixed functional and territorial structure, while resources pooling distributed among enterprise-partners are monitored through computer network integration. The major revenue source is secured by means of rapid innovation promotion, which, in its turn, is enforced by high-tech production. Such products are becoming more and more intellectual involving a high-tech production potential increase. Thus, the intellectual potential has emerged into the production primary factor. Socio-economic mode is based on the global economic principles, high "living standards" and self-actualization [4]. The transition to the sixth step of the technological mode is performed where nano- and bio- information - communicative technology clusters are base-types.

Significant fundamental changes have also proceeded within the higher professional education system involving the development of an innovative university and further modeling and re-shaping of existing curriculum. In this case, the basic principles are: training trajectory tailoring; personal orientation; autonomous management; global training level quality; integration of education, research, innovation and production activities; shaping innovative mentality and training students for future innovative teamwork (including, global teamwork) within the framework of sustainable development; high personal cultural level. The learning process itself has changed through its content and applied technology. Previous lecture-seminar model in the education process has been substituted by the so-called "e-learning" model, which, in its turn, is transforming into "smart education". Integrated grading systems are becoming prevalent in the universities.

Based on the in-depth analysis of existing alterations in the post-industrial community within the framework of engineering education and national technological development, the priorities in developing Russian competitive and functionally effective engineering education systems could be defined to further the innovative sustainability of the country and to establish its leading position in the global space. The key issue- financing budget and effective appropriation of financial resources. To be a world leader, the financing of engineering education and science should be consistent with that predicted by the global analogous indicators.

The effective implementation of the Doctrine, as a benchmark for the state, business and higher professional education systems, could be achieved only in two cases: (1) if there are answers to the following questions- what to do and how to do it and (2) if there is an explicitly stated implementation mechanism.

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UDC 378.146
(Universal Decimal Classification)

Requirements applied to engineers in view of Modern Industrialization and the ways of their fulfillment

Moscow State Technical University of Radio Engineering and Automation (MIREA)
Sigov A.S., Sidorin V.V.

The successful implementation of the concept "Modern Industrialization" requires engineers who have completely new set of competences. Both new requirements to the qualification of engineers based on the analysis of the main features of Modern Industrialization are presented and the specific features of modern system of higher technical education are considered. The cluster approach to the organization of educational, scientific and innovative activity as the most effective method to the formation of human resources potential in term of Modern Industrialization is considered in as well.

Sigov A.S.

Sidorin V.V.

Key words: *Modern Industrialization; engineers' qualification; cluster approach; professional, social and individual competencies; educational, scientific, and innovative cluster; engineers' qualification certification, management of competencies.*

The key statement of strategy "Modern Industrialization" is that " ... only modern and developed industrial sector can ensure rapid and high quality economic growth, as it is industry that will make the most rapid increase of labour efficiency, which will cause a multiplicative effect in other sectors."

Specifying the strategy activity areas, one faces the problem of human resources in achieving the objectives required to perform the tasks of Modern Industrialization: rapid economic growth, diversification and modern highly developed economy. The main driving force of stable economy growth and its competitiveness should be the industrial sector. For this reason it is engineers who play the leading role in human resource of new economy.

Despite the determining role of engineers in the industrial development in view of Modern Industrialization, there are a number of questions.

The first question is if the modern experienced engineers and young graduates are ready to solve the tasks of Modern Industrialization. The second one is if the training of modern students in technical universities meets the requirements of Modern Industrialization, if the future graduates will be ready to take an active part in solving the tasks.

The second question is connected with the following problems:

- The educational programs determined by the Federal State Educational Standards (FSES) are not fully relevant to Modern Industrialization.
- The graduates from the technical universities with FSES educational programs are not in high demand with employers. The enterprises-employers are not fully satisfied with graduates' professional level.
- The efficiency of training technology, which is the way of engineering competencies development.

The third question depends mostly on the answers to the first two questions:

what new or additional competences should the engineer have for successful problem solving in view of Modern Industrialization? The answers to these questions can be found while analyzing the main statements of Modern Industrialization concept.

Requirements to the "new" engineer for Modern Industrialization.

The creation of new efficient working positions and, as a result, of new modern productions necessitates the engineering staff who know not only modern technologies and equipment but can forecast new tendencies in technology development in the main and related professional fields. This new engineer's quality can be determined as his/her ability to priority development or advanced creativity.

The demand on development and remodeling of existing enterprises, as well as the implementation of new small and medium-sized enterprises to support the developing infrastructure makes the managerial function of an engineer more important. But this process also makes this function change basically: the engineer as a technical executor of management solutions turns into the leader and manager of manufacture, an enterprise or a branch who forms their development strategies. Engineering approach, ingenuity, the ability to solve non-standard tasks under new and unpredictable circumstances based on knowledge and experience fully meet the requirements of stable and competitive growth of economy, diversification, reduction of raw material dependence, as well as technological and infrastructural remodeling implementation. It is the leading role of engineer that can ensure efficient development and remodeling of enterprises, branches and Modern Industrialization on the whole. To achieve the aims mentioned above the engineering and technical image of a graduate should be based not only on deep knowledge in professional and fundamental science such as mathematics, physics, and chemistry but also on their competences in modern management technologies, social and economic activities. The managerial function of a contemporary and future engineer is inseparable from his/her engineering responsibilities in view of Modern Industrialization. It is impossible to divide management and engineering activities in new economy.

The management of high-tech production, its development and competitiveness need synergetic combination of engineering and management competences in an engineer of a new type. A modern and future engineer should be a manager and a leader at any level. The engineer should be a company's image who chooses its strategy based on his/her engineering creative thinking and broad-based knowledge. That means that the engineer's competence set should comprise knowledge and skills in management, economy and law.

The principle of invisible management, i.e. the best one, which is based on the so called "presumption of non-management", means, on the one hand, absolute quality confidence of the management objects: goods, processes, services and all the activities related to them – design, production, use and maintenance. On the other hand, it means the highest producer's responsibility for the product quality including safety and ecological compatibility. Such confidence can be guaranteed not only by high professionalism of engineering staff but also by engineer's personal and social responsibility. To develop the social and personal engineer's competences in terms of effective management of sustainable development and high quality standards is the topical task and an essential condition of successful Modern Industrialization.

Cancellation of tariff and other barriers and, ultimately, formation of a united economic area will stimulate productive development of Russia, which will increase competition on production, labour and education markets. To ensure product competitiveness it is necessary to use engineers' advanced creativity combined with their high professionalism. Engineers' competitiveness on labour market can be achieved by the combination of traditions and values of classical Russian engineering school with adaptiveness to dynamically changing challengers of internal and external environments of engineering education. To meet the competition the engineers of Modern Industrialization should be formed and developed according to the model: wide range of professional competences + deep functional knowledge and skills + readiness to "readjustment" or retraining. The ability to be easily retrained in a wide professional spectrum is possible due to a new approach to the formation of engineering qualifications and new technology of engineer's competitiveness development. The essence of the technology is a permanent academic support of graduates by universities.

Encouragement of direct foreign investments in financial and technological resources makes the "new" engineers be responsible for the consequences of the financial and technical policies developed by them. These requirements need such competences as business project development, communicative technologies, knowledge in finance, basic management psychology and business communication. Knowledge of the most successful world enterprises' organizational culture, second language skills are no longer cultural competences but professional ones. Study placement, double-degree programs, additional education, including business education – these are the most prospective ways of development of the engineer that meets Modern Industrialization requirement.

To increase labour efficiency and to create new efficient working positions it is necessary to add management and leading skills to engineer's competence set. The engineer should be able to use both material and non-material motivators, to present staff's material welfare as a result but not the reason for the changes.

Transition to "non-resource" economy, which contributes to eliminating the risk of raw material dependence and upgrading the existing enterprises can be achieved through high-tech production development. The main driving force to solve these tasks is engineers with strategic thinking, system approach to enterprise or branch at national and global levels.

Summing up, it is possible to present the requirements to engineers in view of Modern Industrialization in the form of table (Table 1).

Having defined engineering requirements to implement Modern Industrialization, one can pose the following question: Do the contemporary engineers and graduates meet these requirements? To answer this question it is necessary to analyze a modern engineering training system..

Engineering training system in Russia.

The aim of modern higher school training system is "... to train a specialist of a certain level and qualification, who can be competitive in the labour market and knowledgeable in his/her professional field, have experience in relevant subject areas and be able to assume responsibility. The specialist should perform efficiently his/her duties meeting the global standards and be ready for social and labour mobility..." (Fig.1). The basic regulatory document that determines syllabus and training process is "Educational Programme of Higher Professional Education ", which relates to a particular professional field and qualification.

The minimum number of obligatory subjects is determined by Federal State Educational Standards. In these frames the educational programs can highly vary depending on employers' demand.

Nevertheless, the agreement on the requirements to the graduates' competences between the universities and enterprises (employers) has not been reached yet, which makes it impossible to train graduates-on-demand and ensure their competitiveness in the labour market. One of the reasons is that universities and enterprises (labour market) have different evaluation criteria (Fig.2).

The contemporary Russian higher education system has some disadvantages. It has no effective methods to focus on consumers, and enterprises-employers. There are no evaluation criteria on graduates' competitiveness. The reason for the problems mentioned above is the absence of (or weak) feedback from the consumers and the labour market.

Matching the requirements to "new" engineers with the contemporary educational programs, it becomes obvious that nowadays the graduates do not fully meet these requirements. (Table 2) [1,2].

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Table 1. Engineer's Qualifications for Modern Industrialization.

№ Qualities, qualifications, competences
1. Advanced creativity
2. Knowledge in modern technologies, equipment and IT technologies
3. Leadership skills
4. Management skills
5. Use of management technologies, quality management, human resource management and management psychology
6. Cultural, social, economic and law competences
7. Communicative skills, business communication
8. Strategic thinking, systems approach
9. Second language skills
10. Sociality, tolerance, open-mindedness
11. Knowledge in financing activity
12. Responsibility, discipline, team-working abilities
13. Ready to accept enterprise's organizational culture
14. Ability to develop his/her professional competences to the competitive level, ready to change professional field and to be retrained

Table 2. The Extent to Which Graduates Meet the Requirements of Global Labour Market

№	The quality required	Required by educational program	Meet the requirements of Modern Industrialization
1	to know modern technologies used in the world	partly	partly
2	to know modern foreign equipment	no	no
3	to know Russian and foreign regulations, standardization base, management tools, including quality management, resource management, innovative management, HR management, etc.	partly	no
4	to know organizational culture, to have teamwork skills	no	no
5	second language skills	yes	partly
6	to know IT	yes	partly
7	practical experience	no	no
8	advanced creativity	no	no
9	to know IT	not to the full	not to the full
10	leadership qualities, other social and personal qualities	no	no
11	organizing skills	no	no
12	to use management technologies	partly	no
13	to have social, law and economical competences	partly	no
14	to have communicative skills and business communication skills	no	no
15	strategic thinking, systems approach	no	no
16	sociability, tolerance, open-mindedness	no	no
17	to know financing activity tools	no	no
18	responsibility, discipline, to be ready for teamwork	no	no
19	to be ready to adjust to enterprise's organizational culture	no	no
20	to be ready for self-development, changing professional field, retraining	no	mo

Fig. 1. Tasks and Objectives of Educational System.

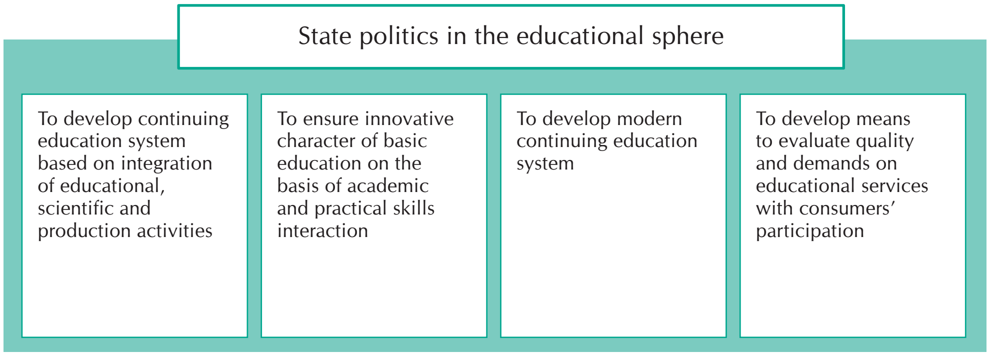
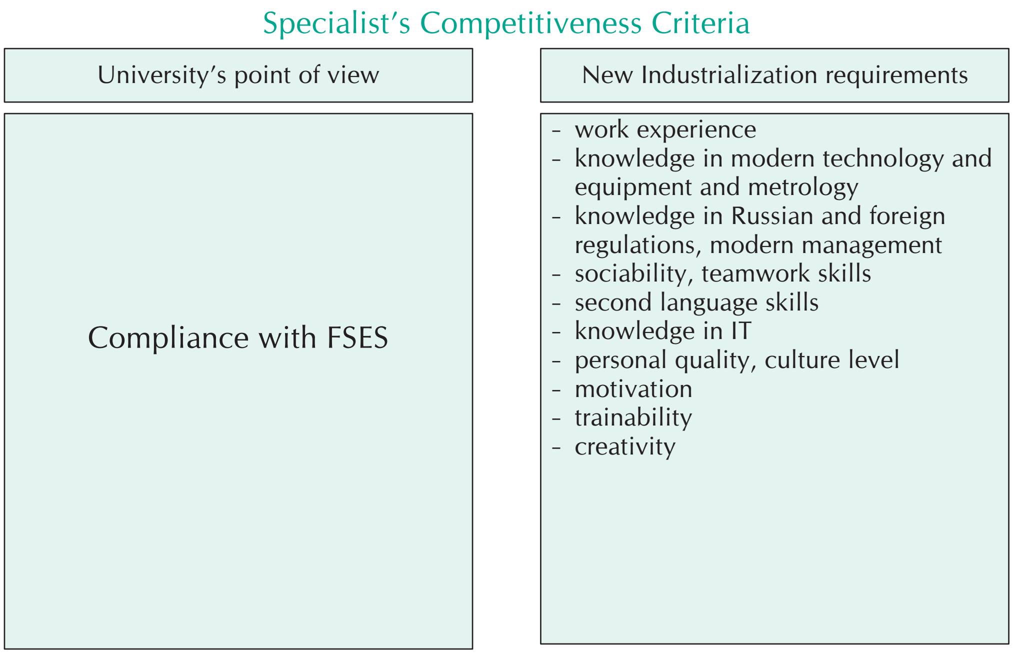


Fig. 2. Problem of Graduates' Competitiveness –Differences Between Competitiveness Criteria in Universities and Requirements of Modern Industrialization.



There are some reasons for this situation: ineffective marketing of educational service market and no consumer orientation. To reduce and remove this mismatch it is necessary to develop special plans and strategies like other world universities do by improving educational programs and curricula [3]. Even the teaching material for first-year students is designed so that it has the connection with their future engineering activity, technical, technological and economical prospects of social development.

Problem-oriented methods and project work allow ensuring new syllabus based on a competence set which includes fundamental and technical knowledge, problem solving by using interdisciplinary approach, skills in project management, sociability and teamwork skills. Thus, to supply enterprises with "new" engineers means to train specialists with a competence set to ensure their competitiveness in labour market.

As for the future graduates to support Modern Industrialization, it is necessary to note that the contemporary two-level higher educational system doesn't have the "engineer" category. Modern" Bachelors" and "Masters" do not fully substitute "Engineers" and are not regarded by the employers as being able to solve "engineer's" tasks that need ingenuity and creative thinking. Having identified the term "engineer" with the word "specialist" the higher education system left out the notion "specialist". That means that the Bachelor cannot be a specialist that is a person with specialty.

A great number of Master degree programs which can be implemented according to FSES, allow the university to develop engineering qualities in the master's educational programs framework. High variability of Master's programs can make a Master acquire engineering qualifications in a necessary combination. But Master's training system and Master's theses have more scientific and research character rather than practical engineering one.

Thus, the engineering staff of Modern Industrialization can consist, firstly, of bachelors, but their qualification level should meet the requirements mentioned above and, secondly, of masters who gave up science and research activities. Both bachelors and masters by having additional engineering training (we mean engineering qualities but not the term) should be considered as engineers who are certified for engineering activities.

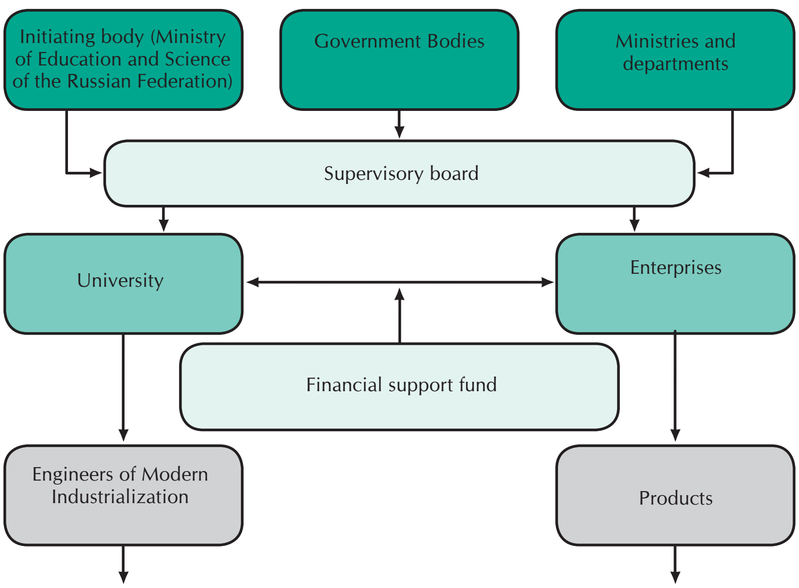
One of the ways of such independent and objective admission is certification of engineering qualifications with further keeping up with necessary professional level by means of retraining course etc. [4,5].

The problem of "new" engineers training can be solved by using cluster approach to university-enterprise cooperation [6]. The cluster approach has proved to be an effective tool to organize dynamic interaction between big and small companies, universities, financial institutions. Being a scientific and educational center, a university coordinates not only scientific and educational activities but also research and innovative ones (Fig. 3) [7-12].

The synergetic effect of cluster approach increases the competitiveness of all the participants and is ensured by coordinated interaction of enterprises and university in all kinds of activities. Net-based interaction encourages strictly oriented chain of knowledge and technology spread [6-12].

Having a great number of factors the development of an engineering

Fig. 3. System of Engineering Training for Modern Industrialization



competence set needs to be coordinated in different spheres. It should be based on principles and methods of a balanced metrics adjusted to the cluster activity and its components.

Cluster participants:

- State represented by initiating bodies
- University
- Enterprises
- Financing parties, grant-giving bodies
- Other governmental and non-governmental organizations interested in trained engineers
- Society.

With engineers highly qualified, innovative orientation of the cluster, technical and production technology "breakthrough" is a realistic expectation in the frame of Modern Industrialization.

A university and enterprises are united in the cluster by common interests and approaches in training competitive specialists (Fig. 4).

The system of "new" engineer training is based on the following principles:

- Priority of requirements to engineers of Modern Industrialization and enterprises-employers;
- University's responsibility for the quality and competitiveness of a specialist;
- Joint training of students in educational, research, production and innovative activities;
- Unity of purpose, mutual interest in joint activity result;
- Balance of responsibilities, rights and resources in the cluster to reach the objectives.

To ensure efficient educational activity the cluster approach involves solving the following tasks:

- Joint (university and enterprises) development of requirements to the graduates' qualifications, curricula, educational programs and their implementation;
- Joint students training with a corresponding distribution of rights and responsibilities;
- Development of evaluation criteria for engineering qualifications in the production process;
- Development of regulatory and procedural documents of technical student training in educational, scientific and innovative clusters.

In an educational scientific and innovative cluster, university is a multidisciplinary higher education institution. The training process is based on studying technical, social and economical subjects, using the gained knowledge and skills in researches conducted under the guidance of teachers and scientists. The combination of educational and research activities as well as practical experience in enterprises will ensure the development of the required set of engineering competences and provide graduates with competitiveness in the labour market. Reaching the required competence level and keeping the corresponding qualification level of graduates and engineering staff are a controlled process aimed at achieving definite learning outcomes. It consists of scientific and methodical support, management, marketing, quality management.

Operating results of educational, scientific and innovative cluster are (Fig.5):

- Trained engineering staff for Modern Industrialization;
- Scientific and pedagogical staff of the highest qualification;
- Engineering staff of enterprises having additional special training courses;
- Research findings, technical and innovative products.

The Efficiency of every cluster activity is provided by the complex of economical, organizational, technical, material, non-material, psychological and other factors.

Modern economical and social conditions, educational program standardization, on the one hand, and the variety of educational paths, on the other, ensure a great choice of similar or relevant courses in universities for enrollees to take.

It causes the universities to choose the most effective and demanded educational path and to look for the best ways of training which involve students in high-level research and development activities.

A special attention should be paid to moral-building activities to develop personal, social and cultural competences of “new” engineers for Modern Industrialization.

The scope of work for the cluster includes development and formalization of requirements to “new” engineers, choice of training methods, benchmark development to match the results with the requirements, etc.

A necessary condition of successful cluster activity is development and implementation of a continuing methodical support of students and graduates on every educational stage and during their professional life. Another important condition is engineering certification, which constantly states their conformance to the requirements.

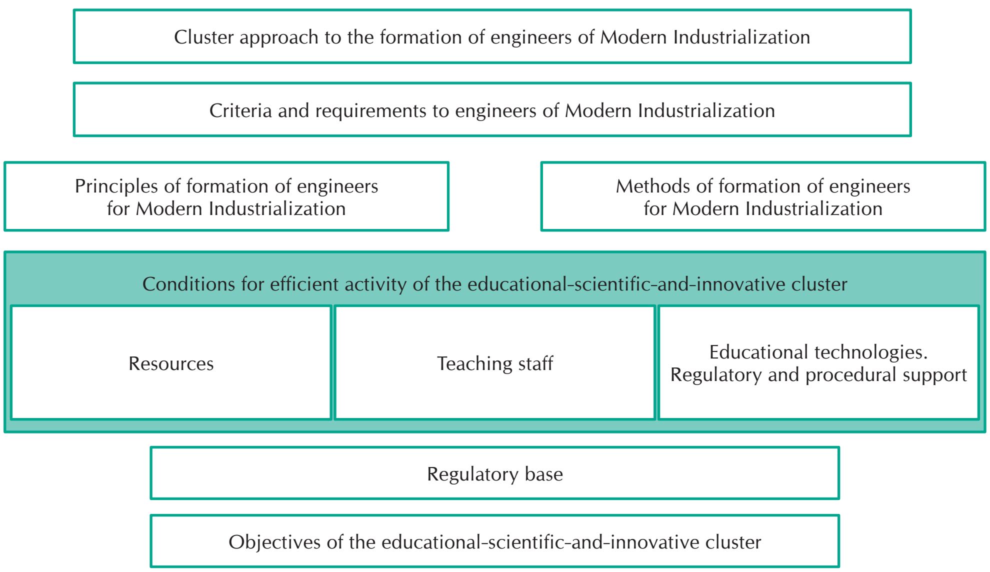
The peculiarity of the engineering certification is periodic independent revision of the competence requirements enlisted in the programs to conform to ever-changing technical and technological conditions. The main task of specialists’ certification is to provide and prove engineer-level skills and competences required during the professional career to assist all the interested parties- state, employer, trainee and an educational institution.

Engineering certification in an educational process is an additional tool of graduates’ evaluation. It guarantees the required level of engineering competences to ensure their competitiveness and employers’ satisfaction.

To ensure graduates having the required level of engineering competences it is necessary to provide high-level educational technologies and competence management of academic teaching staff. The educational programs should be up-to-date as well as human resource management in university should conform to the main tasks and objectives.

It can be performed by developing and implementing the system of competence management in university. This system provides efficient use of knowledge, skills and experience of highly qualified academic teaching staff and support staff of university.

Fig. 4. Structure of Cluster Approach to the Training of Engineers of Modern Industrialization



To implement the mentioned system, it is essential to provide continuing teaching staff training based on continuity principle combined with material and non-material motivation.

The cluster approach and efficient university-enterprises partnership combined with a set of formulated requirements will provide:

- the possibility of creative problem solving, to generate new ideas, to transfer them into new knowledge, products and technologies;
- the possibility to use the results of theoretical and practical knowledge acquisition while designing and making new innovative products;
- the ability to acquire new knowledge and skills and use them in the related activities;
- the ability to set objectives in the sphere of innovative product development and production;
- the ability to develop a system of corporate performance management;
- the ability to adopt and to ensure author's supervision of innovative products;
- the ability to evaluate performance management system aimed at manufacturing and selling innovative products.

Fig. 5. Results of Educational Activity of the Educational-Scientific-and-Innovative Cluster

	Requirements are set by	Quality Standard
Graduates	Ministry of education and science – FSES Employers	FSES conformity
Scientific and technological products	Consumers	Conformity to requirements specifications
PhD and Doctors	Ministry of education and science – State Commission for Academic degrees and Titles (SCADT)	Requirements of SCADT
Advanced professional training	Ministry of education and science, Enterprises – partners, employers	Tasks and objectives of a training program
Additional education	Enterprises-partners	Additional specific requirements of an enterprise

Human resources of enterprises and scientific institutions

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UDC 378
(Universal Decimal Classification)

Designing National Engineering Certification System Based on International Standards

National Research Tomsk Polytechnic University
P.S. Chubik, A.I. Chuchalin, A.V. Zamyatin

This paper describes the issues involved in the development of the Russian National Engineering Certification System within the framework of the National Competency and Qualification System (NCQS). Example of foreign experience in engineering qualification licensing is highlighted, including NCEES (USA). Integration of Russian National engineering certification system into different international structures, such as FEANI Register, APEC Engineer Register, and EMF has been highlighted. The development version of the systematic interaction between engineering education accreditation and engineering certification centers, involving partners (institutions, enterprises and professionals) has been proposed, as well as the interaction with monitoring committees.

Key words: *qualified engineer, licensing, accreditation, certification, registration, international recognition.*

P.S. Chubik

A.I. Chuchalin

A.V. Zamyatin

Promoting the professional competence of Russian engineers is the major national long-term challenge, which, in its turn, furthers the dynamic technological development of the country.

In developed countries (USA, Great Britain, Japan, etc.) this problem-solving involves existing systems of licensing and/ or certification and registration. In most cases, these systems are the second step in the quality certification of engineers. The first step includes the public-professional accreditation of academic curricula in technology and engineering, confirming the quality of basic engineering education in a university. As a rule, both stages are implemented by nonprofit professional organizations, using corresponding criteria and procedures.

Administrative-legislative status of accreditation and certification organizations, as well as other important regulatory issues in engineering education and engineering are based on the advanced regulatory legal framework. Licensed engineers (professionals) are a select group.

An example is the National Council of Examiners for Engineering and Surveying (NCEES) in the USA. NCEES is responsible for the administration of the exams that engineers must pass in order to become certified as a Professional Engineer. It develops, administers and scores the examinations used for engineering licensure in different states of the United States.

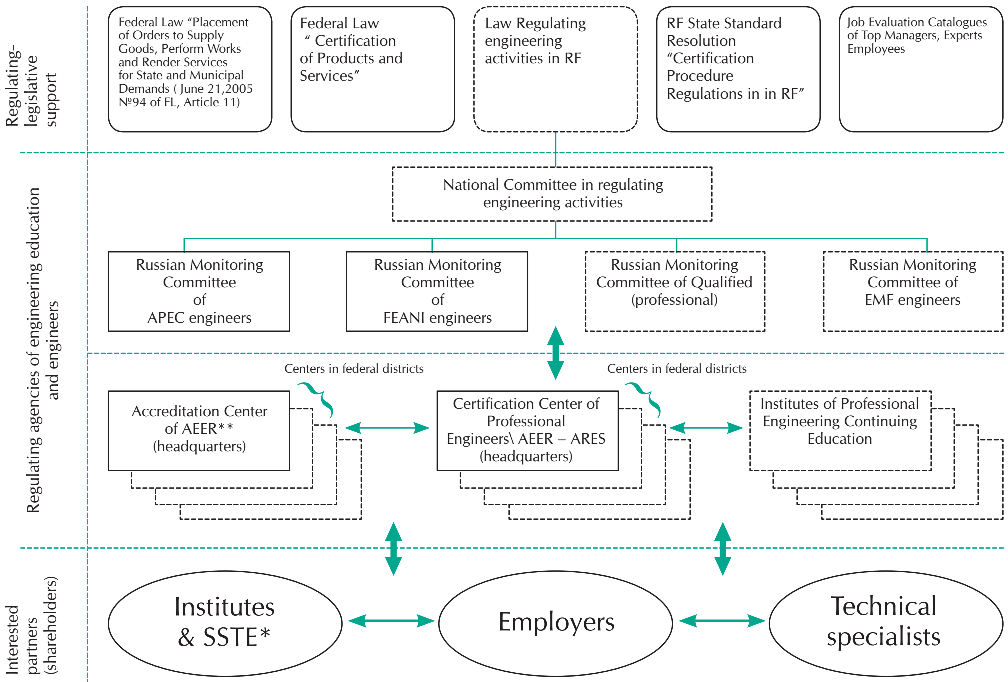
Candidates who have met specific qualification requirements receive an engineering licensure as a professional engineer. Engineering licensure is for those engineers involved in the public service sector. Not all engineers become licensed, especially those working in private companies. However, most engineers do achieve licensure to enjoy the professional benefits that accompany this distinction- career options as career promotion or high salary.

There are more than 470 thousand licensed engineers in the USA, who embrace one-third of the total number of professionals. In Russia there are approximately 5 million technical experts (i. e. engineers of different professions). About 10% of this total (500 thousand engineers) are highly-qualified professionals working in the top-priority and high-tech industrial sectors and, at the same time, significantly influence the technological development of the country. Based on the experience of different countries, including the USA, 20-30% of these professionals (i.e. about 100-150 Russian engineers) could be licensed and become licensed engineers, i.e. "the select group" of the country.

One scenario in developing a National Engineering Certification & Registration System of "elite" engineers in Russia is to establish a National Committee in regulating the engineering activities.

It is assumed that the National Committee in regulating the engineering activities would coordinate the work of the Russian Monitoring Committee of Professional Engineers, administering the certification of engineers according to national (state) criteria, as well as Russian Monitoring Committees of international organizations FEANI, APEC Engineer Register and EMF providing the engineer with

Fig. 1 Overview Diagram of National Engineering Education Accreditation System and Certification of Engineering Qualifications.



** SSTE - Special Secondary Training Establishment*
*** AEER – Association for Engineering Education of Russia*
**** ARES – Association of Research and Engineering Societies*

licensure in accordance with international standards [1,2].

Conversely, the national monitoring committees will administer the performance of accreditation and certification centers, as well as Institutes of Professional Engineering Continuing Education, located in different federal districts.

Services of the National System of Certification and Registration of Professional Engineers are for all interested partners, such as technical institutions (SSTE), employers (enterprises, companies, etc.) and the engineers (i.e. different technical specialists)

In designing the National System of Certification and Registration of Professional Engineers it is viable to observe the following steps:

- develop and implement the regulatory and legal framework administering the role of those public-professional organizations responsible for developing relevant professional engineering requirements, criteria and certification and registration procedures, as well as requirements for further professional engineering training;
- develop and implement such incentives that would further not only the introduction, but also the integration of certified professional engineers (certified according to national and international standards) into non-public (private) companies and businesses;
- develop and implement both incentives and forcing regulations to further not only the introduction, but also the integration of certified professional engineers (certified according to national and international standards) into public corporations and public-private partnership companies.

The procedure implementation of designing the National System of Certification and Registration of Professional Engineers involves respective amendments and additions within the existing regulatory and legal framework (Federal Law "Certification of Products and Services", Federal Law " Further Training Education", Federal Law "Placement of Orders to Supply Goods, Perform Works and Render Services for State and Municipal Demands (June 21 2005 №94 of FL, Article 11), RF State Standard Resolution "Certification Procedure Regulations in RF", Job Evaluation Catalogues of Top Managers, Experts and Employees).

The first step in designing the National System of Certification and Registration of Professional Engineers is to complete the draft of Federal Law "Regulating Engineering Activities in RF", which, in its turn, should highlight such issues as the development of engineering education and engineering in the context of today's Russia.

At present the National System of Competency and Qualifications (NSCQ) is being developed and is coordinated by the Autonomous non-profit organization "Agency of Strategic Initiatives in Project Promotion" (ASI).

In this case, the National System of Certification and Registration of Professional Engineers should be an integrated part of the National System of Competency and Qualifications (NSCQ). The first step could be the establishment of a federal network of Accreditation Centers of Engineering Education and Engineering Certification (Table 1). The target group involved in the successful implementation, design and execution of such Accreditation Centers of Engineering Education and Engineering Certification are mainly three adopter categories:

1. Educational designers of academic programs in technology and engineering and university faculty.

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Table 1

№	Activities	Expected result (outcome)	Involved participants
1.	Analysis of latest global experience in designing the regulating systems of engineering education and engineering, as well as Russian experience in this area	1.1. organizing a study team (ST) including authorized representatives of interested parties; 1.2.fundamental principles in designing the regulating system of engineering activities	- interested RF ministries and executive departments: RF Ministry of Education and Science; RF Ministry of Economic Development and Trade (MEDT); - representatives of public professional associations: Association for Engineering Education of Russia (AEER), Association of Research and Engineering Societies (ARES), Chamber of Commerce and Industry (CCT), and others
2.1	Motivation and incentives of interested parties (institutions, employers, engineering specialists) to further active involvement in the public-professional accreditation and certification professional procedures by amending the existing legislative regulations	2.1.1 set of documents including respective amendments and additions within the existing regulatory and legal frameworks 2.1.2. discussion of proposed amendments in relevant ministries and executive departments 2.1.3 submitting proposed amendments to Federal Assembly of the Russian Federation, their adoption and enforcement	- study team (ST) - Agency of Strategic Initiatives in Project Promotion (ASI) - relevant ministries
2.2	Project draft of the Federal Law "Regulating Engineering Activities"	project of Federal Law "Regulating Engineering Activities"	Study team (ST)
3.	Establishment of headquarters within existing Certification (ARES) and Accreditation (RSEE) Centers, including approved standard organizational support Establishment of Certification and Accreditation Centers in every federal district	existing Accreditation Centers of Engineering Education and Certification of Professional Engineers (headquarters- one in every federal districts)	Study team (ST) President Administration representatives of RF Regional administrations Regional CCT
4.	Follow-up improvement and enforcement of Federal Law "Regulating Engineering Activities" in view of the real-life experience in designing and executing the National System of regulating engineering activities	Federal Law "Regulating Engineering Activities"	ASI Study team (ST)

Curriculum planning is based on the requirements for academic programs and professional competencies, which, in its turn, furthers the program-on-demand and future international accreditation of these programs;

2. University graduates in technology and engineering, those involved in professional activities and interested in national and international certification and registration to enhance their competitiveness not only in the domestic labour market but also in the global one;

3. Employers in the high-tech economic sector interested in promoting domestic and global competitiveness owing to the national and/or international certified engineers within the company itself. This group acquires a competitive position in national and international tenders, as well as the possibility of signing government and international contracts.

The existing in-process materials and experience of the project promoters further the successful implementation of developing the National System of Certification and Registration of Professional Engineers. Association for Engineering Education of Russia (AEER), a member of the European Network of Accreditation in Engineering Education (ENAEE) and Washington Agreement (Washington Accord), has developed and been successfully implementing the program accreditation criteria and procedures in accordance with international standards. More than 200 Bachelor and Master degree programs, as well as professional graduate programs of leading Russian and Kazakhstan institutions have been accredited, being awarded EUR-ACE Label. Graduates of such accredited institutions (i.e. accredited programs) can be entitled European Engineer (EurEng), registered in FEANI Register and, in the future, receive the "European Professional Engineering Card" through the Russian Monitoring Committee FEANI. In 2010 AEER has become an authorized organization in Russia to administer international certification of engineers in accordance to APEC Engineer Register standards.

Based on the international standards of APEC Engineer Manual and IEA Graduate Attributes and Professional Competencies AEER has developed and successfully implemented regulating-organizational procedural framework of the professional certification systems [3]. In accordance with the international standards of APEC Engineer Register, more than 60 professional engineers in high-tech enterprises have been certified in the Certification Center of Engineering Education and Engineering, National Research Tomsk Polytechnic University.

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OUR AUTHORS

ALEXANDROV
ANATOLI ALEXANDROVICH

DSc. (Engineering Sciences)
Professor, Rector
Bauman Moscow
State Technical University

E-mail: bauman@bmstu.ru

GOLOVNYKH
IVAN MIKHAILOVICH

DSc. (Engineering Sciences)
Professor, Rector
National Research Irkutsk State
Technical University
Full Member of RANS and
International Higher Education
Academy of Science
Honoured Member of Sciences RF

E-mail: rector@istu.edu

ZAMYATIN
ALEXANDER VLADIMIROVICH

DSc. (Engineering Sciences),
Associate professor
Vice-Rector, Cybernetics Institute
National Research Tomsk
Polytechnic University

E-mail: zamyatin@tpu.ru

KARPIK
ALEXANDER PETROVICH

DSc. (Engineering Sciences)
Rector, Siberian State Geodesy
Academy
Honoured Member of Higher
Professional Education RF

E-mail: rector@ssga.ru

KOSHOVKIN
IVAN NIKOLAEVICH

PhD. (Engineering Sciences)
CEO, JSC TomskNIPIneft

E-mail: Koshovkinin@nipineft.tomsk.ru

KUTUZOV
VLADIMIR MIKHAILOVICH

Dsc. (Engineering Sciences)
Professor, Rector
St. Petersburg State Electrotechnical
University "LETI" n.a.V.I.
Ulyanov(Lenin)
Laureate of State Prize of RF in
Science and Technology (2002)

E-mail: vmkutuzov@eltech.ru

LATYSHEV
ANDREI SERGEEVICH

Deputy Manager, Human Resources
Department
JSC TomskNIPIneft

E-mail: latyshevas@nipineft.tomsk.ru

LYUBANOVA
TATYANA PETROVNA

PhD. (Engineering Sciences)
Professor, Don State Technical
University, Department of
Engineering Economics and
Management
Honoured Member of Higher
Professional Education RF

E-mail: oferta 2008@mail.ru

LYSENKO
NIKOLAI VLADIMIROVICH

DSc. (Engineering Sciences)
Professor, Vice-Rector
St. Petersburg State Electrotechnical University "LETI"n.a.V.I. Ulyanov(Lenin)

E-mail: nVlysenko@eltech.ru

MESKHI
BESARION CHOKHOEVICH

DSc. (Engineering Sciences), Professor
Rector, Don State Technical University
Honoured Member of Higher Professional Education RF
Laureate of State Prize of RF in Education

E-mail: reception@donstu.ru

PODLESNIY
SERGEI ANTONOVICH

Professor, Counsel of Rector
Siberian Federal University
Member of Executive Board, Association for Engineering Education of Russia
Honoured Member of Higher Professional Education RF

E-mail: spodlesnyi@sfu-kras.ru

POKHOLKOV
YURI PETROVICH

Dsc. (Engineering Sciences), Professor
President, Association for Engineering Education of Russia
Head of Organization and Technology of Higher Professional Education Department
Honoured Member of Sciences RF
Laureate of State Prize of RF in Education (2011)

E-mail: pyuori@mail.ru

SIGOV
ALEXANDER SERGEEVICH

DSc. (Physical and Mathematical Sciences)
Rector, Moscow State University in Radio Engineering, Electronics and Automation (MSU REEA)
Member RAS
Honoured Member of Sciences RF
Laureate of State Prize of RF, Government Prize in Education and in Engineering and Technology, Prize n.a. Lomonosov in Science and Education

E-mail: rector@mirea.ru

SIDORIN
VICTOR VICTOROVICH

DSc. (Engineering Sciences),Professor,

Vice-Rector, Quality Management Moscow State University in Radio Engineering, Electronics and Automation
Head of Design and Production of Radioelectronic Means Department
Honoured Member of Higher Professional Education RF
Laureate of State Prize of RF

E-mail: sidorin@mirea.ru

CHERNOV
ARTEM GENNADIEVICH

PhD. (Engineering Sciences)
Academic secretary
JSC "TomskNIPIneft"

E-mail: chernovag@nipineft.tomsk.ru

CHUBIK
PETR SAVELIEVICH

DSc. (Engineering Sciences),
Professor
Rector, National Research Tomsk
Polytechnic University
Vice-President, Association for
Engineering Education of Russia
Honoured Member of Sciences RF

E-mail: chubik@tpu.ru; rector@tpu.ru

CHUBIK
MAXSIM PETROVICH

PhD. (Medical Sciences)
Director of Information - Research
Center
National Research Tomsk
Polytechnic University

E-mail: mchubik@tpu.ru

CHUCHALIN
ALEXANDER IVANOVICH

DSc. (Engineering Sciences),
Professor
Vice-Rector, Education and
International Affairs
National Research Tomsk
Polytechnic University
Member of Executive Board,
Chairhead of Association for
Engineering Education of Russia

E-mail: chai@tpu.ru

SHAPOSHNIKOV
SERGEI OLEGOVICH

PhD. (Engineering Sciences)
Associate professor, Department
of Quality Assessment and
Management
St. Petersburg State Electrotechnical
University "LETI"n.a.V.I.
Ulyanov(Lenin)
Supervisor, Information-
Methodological Center in
Engineering Education

E-mail: soshaposhnikov@gmail.com

SHUMSKAYA
NATALIA NIKOLAEVNA

PhD. (Engineering Sciences)
Vice-Rector for Teaching and
Studies, Don State Technical
University
Honoured Member of Higher
Professional Education RF

E-mail: nshumskay@dstu.edu.ru

Summary

THE BAUMAN MSTU: EXPERIENCE, TRADITIONS AND INNOVATIONS IN ENGINEERING AND SCIENTIFIC STAFF TRAINING

A.A. Alexandrov
The Bauman Moscow state technical university (The Bauman MSTU)

The article deals with the whole totality of problems concerning engineering education and universities' activity at the present stage of education system reform. It analyzes topical problems and shows possible ways of their solving In the light of historic experience and training traditions of The Bauman MSTU. In fact, it gives the characteristics of a contemporary technical university, the problems of formation of its unique scientific and educational environment which can train engineering elite, use the scientific potential effectively and provide a real universities' contribution into Russian economy modernization.

PROBLEM SITUATIONS IN ENGINEERING TRAINING

A.P. Karpik
Siberian State Academy of Geodesy

The article suggests a competence and qualification approach to formation of engineering training innovative model. The approach takes into account a regional component and is based on integration of cluster interaction of continuing education participants.

ENHANCING ENGINEERING EDUCATION IN THE POST-CRISIS PERIOD OF ECONOMICAL DEVELOPMENT IN RUSSIA

V.M. Kutuzov, N.V. Lysenko, S.O. Shaposhnikov
St. Petersburg State Electrotechnical University "LETI"

In the developing economy of knowledge, the task of establishing and strengthening partnership with industry and the labor market as whole becomes of the top priority. It needs developing a network of organizations interested in mutually beneficial collaboration in the area of training highly qualified engineers, improving the technical facilities of the academic process, conducting joint research, upgrading manufacturing facilities, etc. To make such collaboration a success, it is important to realize how to establish the university-industry partnership based on mutual interests and benefits. The paper presents the experience from St.Petersburg State Electrotechnical University "LETI" in launching and running a University-Industrial Enterprises Strategic Partnership Program aimed at enhancing engineering education at the university.

PROBLEMS IN MARKETING TEACHING IN TECHNICAL UNIVERSITIES

B.Ch. Meskhi, T.P. Lyubanova, N.N. Shumskaya
Don State Technical University (DSTU)

The article describes the DSTUB experience in training engineers in the sphere of techniques and technology who have engineering marketing competencies.

EXPERIENCE IN STAFF TRAINING AND RETRAINING FOR SOLVING DESIGN AND ENGINEERING PROBLEMS IN OIL INDUSTRY

I.N. Koshovkin, A.S. Latyshev, A.G. Chernov
JSC "TomskNIPIneft"

The article describes oil companies' basic requirements for modern engineers who work on designing and development of oil and gas fields. It analyzes and suggests the most optimal ways of interaction between Higher Education Establishment and Enterprise in the sphere of design engineer training. The example of the scientific-research institute shows practical implementation of business-education interaction concepts. It also describes basic approaches to effective staff development and training programs being put into practice.

THE INTERACTION OF THE ENGINEERING EDUCATION WITH HIGH-TECHNOLOGY BUSINESS

I.M. Golovnikh
National Research Irkutsk State Technical University

Nowadays the strong competitiveness for the qualified engineers exists on the labor market. Business and modern level of production allow raising a demand to the quality of the staff training and the existing system of high professional education continues to graduate specialists who are not very well prepared to the production activity. The solution of the problem is to unite the efforts of technical universities and big high-technology companies.

SOME OF THE APPROACHES TO THE NATIONAL DOCTRINE OF ENGINEERING EDUCATION

Y.P. Pokholkov
National Research Tomsk Polytechnic University, Association for Engineering Education of Russia

The article explains the necessity and urgency to develop the national doctrine of Russian engineering education in conditions of new industrialization. It discusses a possible structure of the national doctrine of advanced engineering training in Russia. It describes the management principles of engineering education and the approaches to their implementation.

INDUSTRIALIZATION AS A KEY DRIVER FOR MODERNIZATION OF ENGINEERING EDUCATION. ENGINEERING EDUCATION: TOWARDS NEW INDUSTRIALIZATION

P.S. Chubik, M.P. Chubik
National Research Tomsk Polytechnic University

The paper examines key mechanisms for modernization of engineering education system in Russia in the context of the policy stated by the Russian Government towards new industrialization and main tendencies in development of modern Russian and global engineering education.

SOME APPROACHES TO FORMING THE NATIONAL DOCTRINE OF ENGINEERING EDUCATION

S.A. Podlesniy
Siberian Federal University

In this paper there have been considered some problems connected with forming the national doctrine of advance continuous engineering education in the conditions of new Russian industrialization and economy globalization.

REQUIREMENTS APPLIED TO ENGINEERS IN TERMS OF MODERN INDUSTRIALIZATION AND THE WAYS OF ITS REALIZATION

A.S. Sigov, V.V. Sidorin
Moscow State Technical University of Radio-engineering, Electronics and Automation

The successful implementation of the concept Modern Industrialization requires engineers who have completely new set of competences. Both new requirements to the qualification of engineers based on the analysis of the main features of Modern Industrialization are presented and the specific features of modern system of higher technical education are considered. The cluster approach to the organization of educational, scientific and innovative activity as the most effective method to the formation of human resources potential in term of Modern Industrialization is considered in as well.

FORMATION OF NATIONAL ENGINEERING REGISTRATION SYSTEM ON INTERNATIONAL STANDARD BASIS

P.S. Chubik, A.I. Chuchalin, A.V. Zamyatin
National Research Tomsk Polytechnic University

The work describes the formation of Russian national engineering registration system in the frame of formation of National Competency and Qualification System (NCQS). It shows the foreign countries' experience in licensing for engineering activities, in particular, NCEES (the USA). It underlines the necessity to integrate the Russian national engineering registration system with the international structures, such as FEANI Register, APEC Engineer Register, EMF. It suggests the way to organize a systematic interaction of accreditation centers of engineering education and engineering register centers with interested parties (higher educational institutions, enterprises and engineers) as well as with corresponding monitor committees.

Dear Colleagues!

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

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

The graduates of such accredited engineering education programs can receive the profession degree EUR ING "European Engineer" in the future.

Association of Engineering Education is the only agency in Russia that has the qualifications to certify EUR-ACE. Accredited programs are included in the AEER accreditation program register, as well as, the European register of accredited engineering programs.

All necessary information can be found on the following website:

Accreditation Center AEER www.ac-race.ru.

Contact details:

Tel. (3822) 41-70-09

Tel\Fax (3822) 42-14-78

e-mail: ac@ac-raee.ru

Address: P.O. BOX 119454 Moscow, Russia

78 Vernadsk Prospect, Building №7

Correspondence address: P.O. BOX 634050 Tomsk, Russia

30 Lenin Prospect, Room 328

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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.

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Immediately after the abstract, provide a maximum of 7 keywords

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Editorial board,
"Engineering Education" Journal

ENGINEERING EDUCATION

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Editorial office address:
7 building, 78, Vernadskogo Prospect,
Moscow, 119454, RUSSIA

Telephone/Fax: +7 (499) 7395928,
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