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Elite Engineers for Economy. Who is the Highly Demanded Specialist of Today and Tomorrow?

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One of the deterrents of the economy, nowadays, is the shortage of qualified staff and insufficient qualification of university graduates. While the sixth wave of innovation is actively spreading across foreign developed countries, Russia is stuck at the fifth wave with the level of science and education 15-20 years behind the world's development level. The attempt to jump on the last carriage of the leaving train is a remote possibility. We need to rush ahead. Today, to get leading positions Russia must master convergent technologies and multi-disciplinary approach in development of science and education. Issues of higher education institutions and challenges of training new-type specialists are analyzed in the article.

Key words: convergent technologies, interdisciplinary organization of science, research engineers, scientific schools, dual system, corporate department, learning paths, network university.

What kind of specialists will be required in our region by industries in five or ten years' perspective? «It would, of course, be nice to look further at a more distant perspective of, say, 20 years. Although we are all aware that life runs forward so fast and technologies change so rapidly that it is difficult to predict, what will be going on in 20 years, but the further we can make prognosis, the better. We should look ahead in order to clearly understand which industries can become the growth drivers for entire regions, such as Siberian, Ural, or Arctic regions, and pay precise attention to the areas that will or are already determining new waves of innovations»[1].

In the near and foreseeable future the economy of Russia will primarily depend on oil and gas industry and, above all, on the Fuel and Energy Complex of West Siberian region. What are the areas of its growth?

Idle talks of oil reserves in West Siberia dwindling away in 20 – 30 years are absurd. Residents of the large Tyumen region can be sure of a stable future of their children and grandchildren. There is enough work to do in West Siberia for couple other centuries. Texas is an example of a place, where after a hundred years of intense extraction of resources not a single field has been closed. Emerging improved technologies permit for endless oil extraction. Today, LUKOIL, PJSC, is going to open a new page in developing of West Siberia by establishing joint company together with French company "Total" in Kogalim. The company will be dealing with layers of Bazhenov group. This layer of geological material at the depth of approximately 2000 meters occupies territory of more than 1 million square kilometers. Resources located within the territory of Tyumen region, based on theoretical evaluation, are enormous – about 127 billion tones. Thus, the new project will require specialists of a new formation.

Extreme North is seen as a perspective territory for the oil and gas industry. Today we can observe a new stage in the development of West Siberia. A strategy of Arctic and Subarctic regions exploration is

b development. The launch of the world's largest Bovanenkovo gas field created a multiplicative effect – thousands of workplaces, development of marine and land transportation, extension of rolled steel and tubes production, opportunities for implementation of new infrastructure projects. Construction of a liquefied natural gas (LNG) plant and a seaport Sabetta have been started recently; the project «Northern latitudinal railway» is in progress; new deposit Kamennomysskoye Sea on the cape Parusnyi is also at the development stage [2].

Severe climate of the Arctic region, trickery of the ocean shelf and the need for preservation of nature in the frontier territories necessitate application of high-tech equipment, which absorbs feats of engineering for oil and gas extraction, construction of fully atomized underwater plants for preparation, compression and pumping of gas, providing localization of the complete closed cycle of extraction and purification under water. Humanity still does not possess a truly safe technology for oil and gas production operations for extreme climate conditions of the Arctic region. Thus, we face new challenges, new requirements for the competences of specialists.

A new socio-economic area is to be developed in the northwest of the Tyumen region with its breakthrough mega-project of the 21st century «Ural Industrial – Ural Polar». This project will provide 70 thousand of jobs in the Yamal-Nenets Autonomous District. For the economic reasons this project is currently not in progress. However, the treasures of the Polar Ural will soon be involved in the economic development of the country. Ural remains the reference edge of our country.

In the south of the Tyumen region, on the border of the Uvat, Tobolsk and Vagaysky Districts, a project of comprehensive development of 26 fields with hardly assessable deposits is on the stage of elaboration. According to the forecasts term we will be able to increase the production of hydrocarbons from 10 - 11 to 30 million tons in the midterm, having a lead over Bashkiria and Tatarstan. To think of that, it was only 15 years ago that the territory of West Siberia was considered unpromising in terms of oil reserves. World energy trends are changing dynamically with the introduction of new technologies for deposits development.

Largest, even by world standards, petrochemical complex in Tobolsk allowed our country to switch from importing positions to becoming an exporter of polypropylene. Antipinsky oil refinery near Tyumen is developing; it is expected to provide the population of the region with high-quality fuel.

Technologies of dissolved gas extraction in groundwater, whose reserves only in West Siberia are estimated at 800-900 trillion cubic meters, are waiting to be discovered. So do the diatomite reserves, with the number of 500 trillion tons. It is all building material, crystal and silicon, which is ready for application.

Undoubtedly, the infrastructures of timber complex will also progress. Total timber reserves in the Russian Federation are estimated at 82 billion cubic meters (quarter of the world's reserves). Set calculated annual logging area is about 576 million cubic meters, and only 23% out of it is used.

Tyumen region, so to say, is going through the second wave of industrialization with its project «3D industrialization» and new emerging industries. In 2013–2014 21 plants were built; «investment portfolio» contains more than 280 projects with an investment volume of 1.3 trillion rubles, which promotes creation of 33 thousand work places. The profile of industries is very diverse, including even such unusual ones for our region as steelmaking.

Analysis of the development projects defines two directions for organization of vocational education in the region: training of specialists for most popular professions of the dominant sectors of the economy

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and «small scale» training of specialists for small and medium enterprises.

The first direction is aimed at staff and technological support for global innovation projects. Their implementation will require breakthrough developments in Russian science and technology, and training of specialists, whose qualification meets the accepted international standards. At the same time, these specialists should be capable of working in difficult conditions of the North and permafrost zone. We emphasize that all these breakthrough developments have to be "national achievements», whereas today in the economy, which is the platform for innovations development in Russia, over 65% of oil and gas services are carried out by foreign experts. While in the USA and China only national companies are operating in this sector. What will happen if foreign companies leave our market tomorrow? It can be a threat for the national security.

As for the major oil and gas industry of the region the list of professions and specializations is more or less traditional. Most demanded specialties are: Geology, Exploration and Development of Mineral Resources; Automation and Control; Computer Science and Engineering; Chemical Technology and Biotechnology; Energy, Power Engineering and Electrical Engineering; Life Safety, Environmental Engineering and Environmental Protection. At the same time, new specialties are in need, especially now with the introduction of sanctions against Russia and threat of their expansion. These specialties include Mechanics and Robotics; High Tech and Economy of Innovations; Software Engineering and others. The government of the country contributes to this. It is already in 2015, according to the statement of Vladimir Putin on the last meeting of the Council for Science and Education, that Russian universities will be empowered to provide applicants with state-funded places for new and promising, demanded by the region specialties that do not have state accreditation (it currently takes 5–6 years to get it).

Why are we in need of specialists with unique competences? The existing educational standards are based on the current level of knowledge and technology. However, the attitudes are changing and the most stable thinking models are being destroyed. Demanded specialists of the new formation besides an impressive knowledge background should possess unique technologies, currently hardly developed. Let us have a look at our trump card – the «black gold» – oil. Deposits are discovered following the traditional theory of hydrocarbons bedding, when we are looking for a certain lake, hidden natural reservoir, «super barrel.» Geophysics does not provide us with sufficiently accurate data on the structure of the subsoil and the presence of oil and gas. As a result, oil and gas industry spends huge amounts of money drilling significantly more exploration wells than would be necessary, if the new technologies were used. This leads to unpromising consequences: only one out of 4 or 5 drilled structures contains productive oil and gas reservoirs.

When conducting exploration in permafrost conditions the result is even less perspective as only one out of 5 or 6 drilled exploratory wells is productive, while the cost of construction of one well is about 300 million rubles. As Vladimir Vysotsky used to say: «...we are digging in the money in the Earth».

To learn how to discover oil in the earth's crust it is essential to understand the nature of its origin. According to the original theory of Robert Bembel, the Professor of Tyumen State Oil and Gas University, Doctor of geological – mineralogical sciences, there is no «barrel». «Instead there are vertical channels – geosoliton tubes. Hydrogen goes along these tubes under strong pressure from the planet's core forming hydrocarbon deposits on its way up» [3]. There is a major trunk and numerous veins like in a tree. Getting straight to geosoliton will significantly reduce costs. Professor Bembel is convinced: the richest deposit of Ugra – Priobskoe – would have been discovered 20 years earlier than 1980th but for the geological dogmas. Processes altering the structure, scope and quality of the hydrocarbons are continuously occurring under the ground. 3D seismic combined with high-resolution volumetric seismic can be a possible way of solving this problem during exploration. Or should we already think of a 4D, where time is the fourth parameter?

What do we see as a promising area of technology development? Science and education in Russia are almost 15-20 years behind the process of global development. We are stuck at the level of the fifth wave of innovations. While the train was moving, we were standing. We focused on introduction of «advanced» imported technologies and training of specialists for operating this foreign equipment with the involvement of foreign professors («The West will help us!» It turned out the help was without letting Russians know the secrets of their technologies and their expertise.) Establishment of specialized centers and schools is a weak attempt to jump on the last carriage of the leaving train. It is senseless.

«World leading countries, including the United States, associate the development of the sixth wave of innovation with the development of convergent technologies – NBIC (N – nano, B – bio, I – info and C – cogno). This trend should become a strategic vector of our development, which will allow Russia to rush ahead as we have done previously with nuclear energy or space» [4]. Development of such technologies requires multidisciplinary approach, whilst historically, for many years, science (both Russian and international) was developing within a highly specialized track. For hundreds of years people have built highly specialized system of science and education. On the one hand, this system is unique, because the modern civilization is built upon this system. On the other hand, it turned out to be a deadlock. The country, which will call for formation of interdisciplinary science and drive forward to the creation of a new system, will be among the leaders of the XXI century.

There is no alternative. We are standing behind and need a leap. For converged sciences professionals should be trained in a different way. We need broadly educated people, who can understand different areas of science.

We are not talking about elimination of highly specialized training. But it should take place in parallel with the formation of supradisciplinary specialists. This is crucially important for the formation of a new wave of innovation. The structure of the educational organization is conservative. Development of a university in this context requires its right to form its own standards, curricula and programs.

Nowadays, the duration of engineers' training is typically longer than terms of the technology upgrade. Consequently, the university should forecast the quantitative and, more importantly, contextual need for engineering specialists, especially in response to the changed geo-economic situation. On this basis, state orders and requests for training of engineers should be formed.

Student's future field of expertise should define the methodology of training, the set of competences of the future university graduate. The volume of knowledge and information is huge, but the study period is only 4 years. «Now is the time for the system of technical education to allocate three main roots of training: «linear» engineers, design and process engineers, researcher engineers» [1]. It seems that we can provide training of engineers demanded by industry in each direction by changing the forms of organization and the content of training.

Today, the biggest lack industry is experiencing is the lack of «linear» engineers, in particular, of production line supervisors and production engineers. Mass training of such specialists should be

based on specifically developed, practice-oriented higher education programs. These programs should combine basic natural science and engineering training with practical professional training. A well-known system of a synergy of industrial plants and higher technical educational institutions with some qualitative improvements can become an effective method for practice-oriented learning realization. During such training a student acquires necessary skills on operation of modern equipment and application of technology, which reduce the adaptation period of graduates after graduation. A key principle of linear engineers' activity should be: «Organize and exploit.» It means that they should organize working activity of staff and efficiently exploit modern equipment. Of course, this system should be developed to provide advanced training of linear engineers taking into account specific features of regional industry.

The second and perhaps the main type of engineers trained by technical universities today are the design engineers and production engineers. It is assumed that for this category of engineers the main form of training should be the Project-based Learning, which is based on multidisciplinary project work in the framework of the CDIO concept «Conceive, Design, Implement, Operate». For training this kind of engineers the traditional forms of education should be moved towards the forms aimed at promoting creative potential of students and teachers. For instance, more attention should be paid to teamwork for R&D implementation for industrial companies.

Finally, the research engineers and developers. The mission of such engineers is to create new competitive products, develop convergent technologies through integration of achievements and innovations in various fields. They are the so-called Special operations troops of engineers, who master world-class technologies such as nanotechnology, technologies of supercomputing engineering, advanced technologies of digital production. Research engineers shall solve unsolvable problems and provide innovative breakthroughs for high-tech industries. Such engineers – leading edge and mutually reinforcing – should not be the mass product. Training should be based on the principles of inter- and multidisciplinary approach built upon, first of all, deep fundamental education.

Creating a competitive engineer is time consuming and expensive. It is possible only if having proper facilities and an established and well-developed scientific and pedagogical school. And its formation takes many years. Perhaps, the most important factor is the mentality of the university, its atmosphere. They differ for various types of universites. Classical university develops a cult of science, pedagogical one – a cult of children, technical university is focused on practical efficiency. Here we are talking about different values. These are the values, developed by traditions, which form the university. And the university brand guarantees the quality of a specialist. It is like a jar of pickle brine, whatever cucumber you put in it, you know the final taste.

Tyumen State Oil and Gas University historically established for oil and gas development performs training of specialists for mass professions of the dominant sectors of economy in West Siberian region. University has several world famous science and pedagogical schools: geology and exploration (heads: correspondent members of RAS I.I. Nesterov, A.R. Kurchikov); cryology of Earth (full member of RAS V.P. Melnikov); drilling; development of oil and gas fields; oil and gas processing; hydrocarbons transfer; automation and information technology. A system of continuous education has been launched: college, undergraduate, graduate, and postgraduate education, PhD and Doctor of Science thesis councils, centers for professional development and retraining, which all together execute the concept of Life-long Learning. To be in step with the progress you cannot stick to the principle «one life - one diploma» as it rapidly becomes outdated.

Tyumen State Oil and Gas University works closely together with 189 partner companies. About 60% of the engineers occupying positions in Fuel and Energy Complex are graduates of the university. For instance, more than 1500 employees of "LUKOIL-West Siberia", LLC, are graduates of the Tyumen State Oil and Gas University.

University is recognized as the basis and supportive organization for training qualified specialists for largest oil and gas companies: ROSNEFT, OJSC;

GAZPROM, JSC; LUKOIL, PJSC; Surgutneftegas, OJSC; TRANSNEFT, JSC; NOVATEK, JSC; SIBUR, JSC. Among 150 thousand graduates of the university there are recognized leaders of this industry: Council chair of the Union of Oil & Gas Producers of Russia Y.K. Shafranik, CEOs of large companies: Surgutneftegas, OJSC – V.L. Bogdanov; Gazprom dobycha Yamburg, LLC – O.P. Andreev; Gazprom dobycha Urengoi, LLC – S.V. Mazanov; Gazprom dobycha Noyabrsk, LLC – K.V. Stepovoi; LUKOIL – PERM, LLC – A.V. Leifrid; LUKOIL – KOMI, LLC – P.V. Oboronkov; Garpromtransgas Yugorsk, LLC – P.M. Sozonov, and others.

«Today, during the process of economy diversification in the region ... we are placing stakes on Oil and Gas University in training of engineers. We see, the University successfully copes with this problem»- said V.V. Yakushev, the Governor of Tyumen region.

Being aware of the current issues and forecasting directions of economic development of the region the University puts emphasis on training «linear» engineers by launching programs of applied Bachelor degree (20 students in 2012, 760 students in 2014). Dual system, where education takes place in two institutions, is applied in order to increase professional competencies of students. These two institutions are university and enterprise. This task is not easy as there are legal, financial, communicative and organizational issues emerging. Solution to all these problems can be the establishment of industrial departments on the basis of leading enterprises of the industry.

We find the establishment of corporate departments at large enterprises mutually beneficial and interesting. Companies invest their money and resources and attract their leading experts to the educational process not as charity, but for training engineers in demand for themselves. Companies know that their future depends entirely on the level of their staff qualification. Moreover, all graduates of such departments have an ensured position in the enterprise.

As for the training of research engineers and developers, our experience shows, that it is almost impossible to perform their training within Bachelor programs. Next level of education – Master programs – usually provides continuing education at universities in the same or related fields. However, it is the Master level of education, which is able to train research engineers by integrating a variety of Master programs. Master programs can and should deal with advanced training of engineers for development and application of advanced science-based technologies. Individual learning paths are specially integrated for this purpose. They provide additional training within a Master program of a different specialty including utilization of electronic and distance technologies.

The second direction of engineers' training is the «small-scale» training for small and medium enterprises. Currently, due to the multi-vector diversification of the region's economy, the demand for qualified staff by new enterprises is not fully satisfied. That is why the establishment of a modern Polytechnic College on basis of the Tyumen State University seems very reasonable. It is expected to meet the needs of the region in terms of engineering and technical personnel, and the vacant niche will be occupied.

Another option for comprehensive training of engineers of all types, considering the specifics of the regional

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industry, is the formation of network education system. It will bring together the potential and competences of universities of different profiles under the aegis of the Tyumen State Oil and Gas University with involvement of research institutions and leading industrial enterprises distributed among different regions of the country. Figuratevely, we would call such form a "structured Network University"; it would provide solutions for top-priority issues, assure the development of industry and training of specialists ready to perform professional activity without additional adaptation period.

Each of the above-mentioned problems and solutions is a subject for development and specification. Tyumen State Oil and Gas University understands the problems today and is already implementing a scope of measures to provide the region with new generation of engineers. Elaboration of the whole Tyumen region's economic development strategy for professional education, which binds together the strategy to the south, the Khanty-Mansiisk Autonomous District, and the Yamal-Nenets Autonomous District, is necessary for the breakthrough. It is essential to decide: whom to train, what is the number of these people and who will be doing it. The challenges of the XXI century urgently require it.

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Process Approach Application to Engineering and Education

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"You can't solve a problem unless you first admit you have one"
Harvey McKay

The article is devoted to the implementation of process approach to any kind of professional activity as declared by the ISO 9000 Norm. The importance of evaluating process features: its productiveness, efficiency and adaptiveness, is emphasized. The article underlines practicality of the process approach introduction to educational activities for training competent engineers, who will base their own professional performance on this approach.

Key words: process approach, productiveness, efficiency and adaptiveness of processes, product quality, quality standards.

Any type of action involves certain work functions: steelmaker melts steel in an electric arc furnace, accountant calculates employees' wages, professor teaches students to solve differential equations, etc. How can we envisage realization of all these functions as a whole? Most likely, it should be envisaged as realization of various interconnected actions that are conducted consecutively or in parallel. Today these various actions are generally recognized as processes. One of the founders of modern quality management, E. Deming, stated "Any action can be seen as a technological process and, therefore, can be improved".

Modern management of organizations is based on quality management systems. Ideology of such systems focuses on 8 principles of quality management. The central (ground-breaking) principle is the process approach: **expected outcomes can be achieved more efficiently, if actions and corresponding resources are managed as processes** [1, p. 2-3].

What is meant by application of the process approach? Let's try to understand it by looking at the examples of educational and production activities. Production activity here is the foundry production, which provides main rough materials for automobile, aircraft, machine-tool and tractor production.

Foundry production requires a multifunction technological process. Batch preparation, alloy smelting, foundry sand and core sand mixtures' preparation, casting form and core molding, die casting, cast processing – all are parts of foundry final goods' production lifecycle. When using other methods for cast production: die or ceramic mold casting or consumable pattern casting, such multifunction remains. This brings up a question: "How to achieve required quality of a product in the context of such multifunction?" Overall technological process is divided into sub-processes. Organizational structure of production process (production units, departments, divisions, services) is built upon these sub-processes. Each structural division is responsible for its own sub-process. This is a typical functional organizational structure. What are the draw-backs of such structure?

Let us provide a vivid example from the

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