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

JSC "TomskNIPIneft"
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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.*

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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 techni-

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cal 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 satisfac-

tion 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

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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

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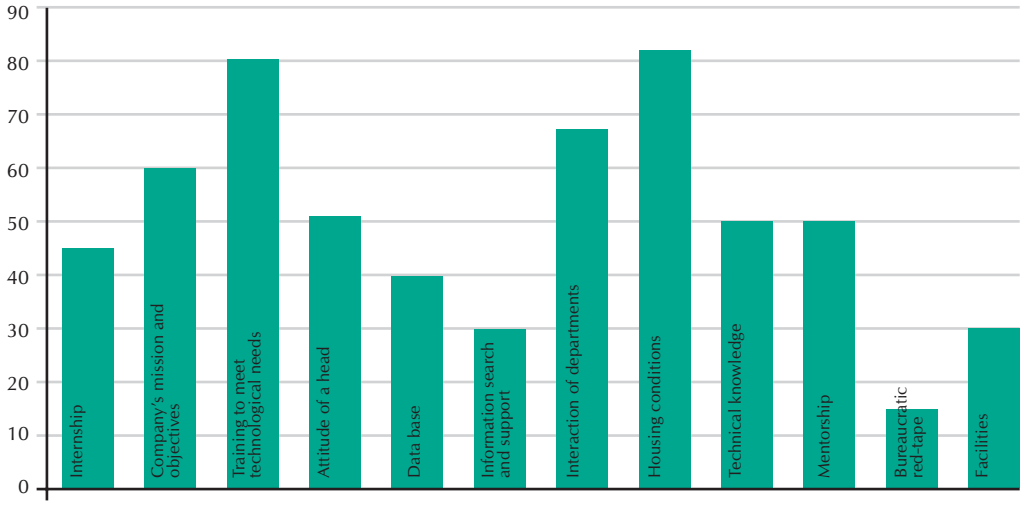
Fig.1. Important Factors in Young Engineer Adaptation Process



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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