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## Innovative Approaches of Graduate Competences Development in Engineering Programs

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## Dear readers!

The challenges sent by the global society to the Russian engineering education call for adequate and prompt responses that assure retaining its level of compatibility and global competitiveness of Russian engineering solutions and developments. Undoubtedly, Russian system of engineering education is undergoing improvement changes on all path segments of specialists' training organization, starting from organization of admission process and designing of educational programs and ending with advanced training of engineers. Among these changes the main one is the transition towards training of specialists, who possess the needed set of competences.

The problem of competences formation of engineering programs' graduates within the training process has emerged a while ago, however, the solution is still far from the final state.

The reasons for the appearance and existence of any problem and this problem in particular are the objective and subjective contradictions that occur due to inevitable changes in nature and all spheres of human activities: in politics, economics, culture, education, engineering, technology and many others.

When it comes to the objective contradictions that led to the emergence of a problem of engineering graduates' competences formation, first and utmost, we need to focus on the contradiction between the philosophical concept of education and the applicative definition of a competence. Education as an act of knowledge consumption can be received without introduction of dynamic practical activities to the educational process. At the same time, competences as a body of knowledge, skills and attitudes, despite its incorporation in the educational knowledge basis, cannot be formed without a solid, if not a prevailing, practical part of education.

As a result, the contradiction between the market (stakeholders') requirements and the educational system (even the system of engineering education) becomes apparent.

We need to bring to notice the contradiction between the arising level of bureaucratic requirements for competences description and methods of its formation and the traditionalistic forms of educational process organization.

Thus, for instance, a stringent requirement to state precisely, when developing the teaching materials, how and in which part of the course the numerous competences are to be formed while studying the discipline contradicts directly with the learning methods, forms of educational process organization and pedagogical approaches used by the faculty.

The other contradiction is between the professional skills of the faculty members and the growing employers' demand for such competences of engineering programs' graduates as the ability to work efficiently within the field of the major (both individually and in a team). It is not infrequent that faculty members teaching technological courses (disciplines) are not familiar with real technological equipment and specific aspects of its exploitation.

In fact, there is a contradiction between the requirements towards the teacher and his/her working conditions.

One of the major contradictions lies in the area of the quality. Nowadaysm many universities have functioning Quality Management Systems (QMS) that are certified according to Russian or even international standards. However, the fact that university has QMA can hardly imply high quality of specialists' training and advancement of their competences' level. The problem is determined by the contradiction between formalization of the process of quality (graduates') development and the real-life conditions, in which this quality is to be formed.

And, finally, there is a contradiction between the need for competences development and credible methods of their assessment (monitoring) within the training process of future specialists. Supposedly, today, it is one of the sharp contradictions that is stipulated in some cases by complete absence of such assessment methods. The existing methods of learning outcomes' control hardly concern the competences.

This issue of the Engineering Education journal presents best practices and innovative propositions of scientific and educational networks on decreasing acuteness of the contradictions mentioned above and, therefore, on solving the problem of competences development of engineering programs' graduates.

We hope that the ideas presented in these articles will be put into use in the best interest of Russian engineering education and will serve as an impulse for generation of new innovative ideas, whose realization will ensure substantial advancement of future engineer's training quality.

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



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# Innovation Approaches to Development of Educational Programs in Field of Engineering

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**The article is devoted to the main conditions of effective development and design of educational programs in the field of engineering.**

**Key words:** educational programs, individual route, competences.

Intensive processes of structural changes, that take place in Russian economy, have stipulated high demand for new age specialists, who could successfully implement these changes with reference to the current historical, economic and political situations in the country. Practical activity, interests of economy, intensive development tracks that are taken by our country, have to prescribe the goals, methods and contents of higher education. However, modern education at national HEIs is insufficiently focused on resolving innovative problems. There is a critical shortage of HEI graduates, who have a high level of technical competency.

It is only possible to ensure a high quality of engineering specialists' training by having an efficiently functioning "Science – Industry – Market" system.

The key role in this system is given to the applied sciences – the source of scientific and technical innovations that determine progressive trends for advancement of products and services both in techno-economic and in social contexts. Undoubtedly, the market demand and the follow-up diversification of the production to a great extent influence the applied research trends. However, the breakthrough innovations that qualitatively alter the end-user characteristics of produced goods and services can drastically affect the market environment. Thus, the dialectics of the "Science – Industry – Market" system's development emphasizes the need for "elite" specialists training based on individual programs in the field of new engineering solutions' synthesis at the interface of different scientific fields that require deep technical knowledge and mandatory experimental research training [1, 2].

At the present time, implementation of the international quality standards, educational and professional standards, credit system and other conceptually new modifications to the system of HEI graduates' training leads to the emergence of some significant challenges in development of engineering educational programs that would be innovative, competitive and creative.

In response to the implementation of credit system to the students' educational process the main goals are:

- standardization of the scope of knowledge;
- creation of conditions for the highest personalization of education;
- strengthening the role of student's self-study efficiency.

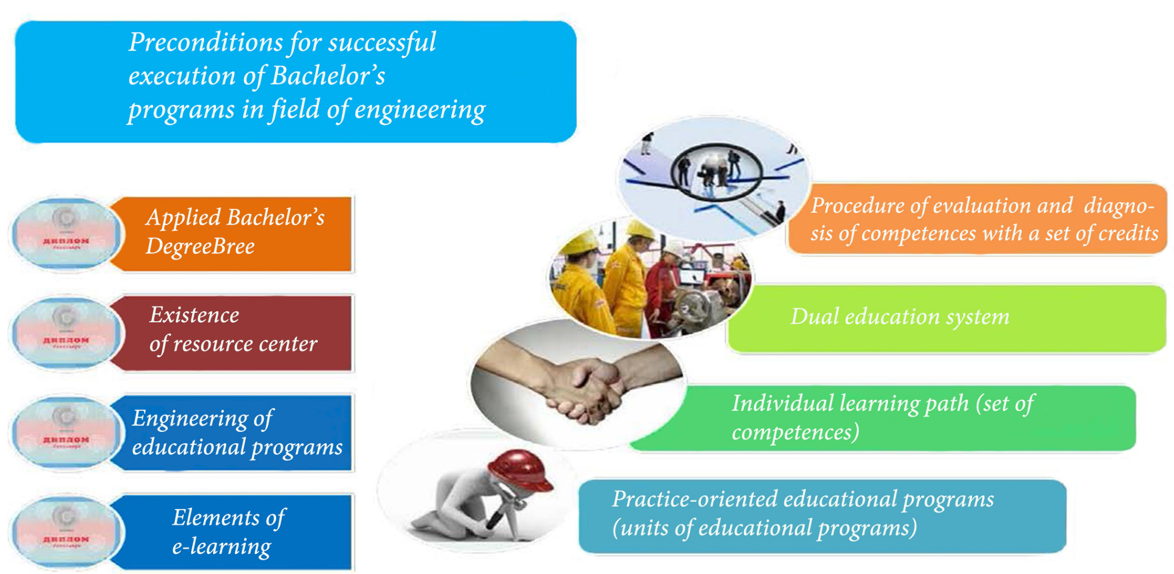
The set goals and objectives of engineering graduates' training are most efficiently reached when the following key preconditions are respected: organization of applied Bachelor's Degree programs (existence of practical training resource center), development of practice-oriented units of educational programs, realization of dual education system, arrangement of individual paths for grasping the educational program, proficient use of e-learning elements, engineering of educational programs (Fig. 1).

Dual education is a form of specialists' training that combines theoretical education within the educational institution (30-40% of study time) and practical education at a production enterprise (60-70% of study time). The main feature of a dual education system is the equal responsibility of both educational institutions and enterprises for the quality of specialists training.

The idea of dual education is to attain its real practical outlines. Interaction of education with business and other market agents is one of the elements of a modern model that is highly sought by the society. Therefore, now is the right time for the global support of the dual education, and the work on its realization should be continued in close collaboration with employers and social partners interested in the development of dual education.

The central object of dual education is the trinity of the participants: educational institution, student – the trainee, and the enterprise. Dual system respects interests of all the participating parties. For the educational institution it gives an opportunity to increase not only the graduates' competitiveness, but also the competitiveness of the educational programs. For the enterprise it gives an opportunity to prepare specialists for itself, to lower the expenses intended for the headhunting and recruiting of employees, for their re-education and adaptation. Thus, it is economically reasonable for employers to "invest" in education, since "on return" they will receive a ready-to-work specialist, who will know in minute detail all the peculiarities of working at

**Fig. 1. Preconditions for successful execution of Bachelor engineering programs**








the specific enterprise (organization). And for the student, in line with the optimum transfer of the professional experience, it provides a completely new degree of socialization: students are involved in real training and testing of their attitude in the real-life working conditions. This is the reason for their fast adaptation to the real working conditions and a high possibility for successful employment after graduating the educational program [3].

When executing educational programs that comprise the dual education system (in our case it is the specialty of "Transport processes technology" and "Service") a specific model is implemented, where students attend classes at university 3 times a week and study the theoretical and fundamental basics of science, and spend 2 days conducting practice learning at the production site [4]. At the enterprise, students work under the direct supervision of specialists – acting workers with high level of acknowledgement. Such enterprises of the Kaliningrad region, as LLC "Autotor", dealer centers of Toyota and BMW, etc., serve as production sites, resource centers for practical training at Immanuel Kant Baltic Federal University.

The advantages of the dual educational programs are as follows:

- elimination of the key problem of traditional forms and methods of education – the gap between theory and practice;
- emergence of extra possibilities for enhancement of engineering specislists' training efficiency;
- diversification of higher education that means enlargement of a variety of proposed educational and professional programs;
- stimulation of a more miscellaneous professional development of students;
- providing interaction, interpenetration and mutual influence of different systems (science and education, science and industry, etc.) that lead to qualitative changes in formation of key professional competences of future HEI graduates;
- increase of professional mobility and graduates' competitiveness on the labor market.

One of the key elements of the dual system is the impartiality of learning outcomes assessment, granting of certificates for "specific" competences, abilities and skills. The assessment of competence level in dual education system is the affirmation of the existence of qualification, of the acquired experience of practical activity. This assessment is focused on the determination of skills in the context of finding solutions for professional problems that require application of information from various fields of knowledge, update of skills and knowledge in new situations, accomplishment of universal types of activity. Thus, we have come to a conclusion that the basis for composition of the dual education system is the designing of student's individual learning path (individual route for grasping the educational program) taking into consideration his/her abilities, personal dispositions and interests.

When speaking of the personalization of the educational process it is essential to note that such methodology allows each student to choose one or another dual educational program and not be dependent in this choice from other students. Such organization of the educational process led to the emergence of a need for student's interaction with a consultant (program manager, tutor, etc.) during the whole study period. Therefore, the following elements were included in the job functions of these specialists: professional consultations on the contents of educational programs and its requirement; specification and correction of student's individual choice and development of a flexible learning path based on his/ her choice in line with the conditions, determined by the educational program.

In our perception, the individual route is a well-defined system that includes requirements (expressed in learning outcomes or fostered competences) for the educational program's learning outcomes, connected with specific requirements for professional activity, as well as it is a plan and a "starting point" for learning the proposed contents.

This, of course, requires not only the "readiness" and motivation of students, but also very deep modernization in terms of design and development of courses (modules), as well as teaching methods and tools or the "teaching interaction" with students from the point of teachers.

In our opinion, in the context of realization of engineering educational programs, it is necessary to introduce the individual route very carefully, since the graduate's professional activity has to differ not only from the point of practical path, but from the fundamental one as well. Therefore, in such a case, a full freedom of choice does not always positively affect students' competence formation. We propose a methodology for development of student's individual path, where the chosen set of competences integrates not only with the educational program's learning outcomes preset by the "purchaser", but also with the courses' (modules') learning outcomes.

Personalization of the educational process implies execution of a full complex of learning methods, which results in an opportunity for each student to show his/her personality, translate the maximum of his/her opportunities into action and, at the same time, stay above the level of advancement set by the educational goal.

The conditions for this approach are as follows:

- determination of the initial level of individual working skills;
- determination of the initial knowledge level;
- allocation of students to different subgroups within one group according to their level of competency (high, middle, low);
- development of various tasks with different contents and knowledge scope for the same program material.

The personalization of the educational process is based on the asynchronous (non-linear) educational method that has the following features:

- high level of students' freedom of choice in terms of the curriculum courses;
- personal involvement of each student in the formation of his/her individual curriculum;
- involvement of the educational program's managers in the educational process (as academic consultants) in order to assist on the formation of educational path;
- mandatory application of the grade rating system for the assessment of student's level of mastery of a course.

Application of the individual educational approach results in justification of the opinion of scientists E. Goncharova and R. Chumicheva, who determine the competences that can be formed through execution of the individual educational trajectory of a student:

- Readiness to solve problems, i.e. an ability to analyze off-standard situations, set goals and correlate them with the aspirations of other people, plan results of his/her activity and develop algorithms for their achievement, assess the results of his/her activity; leads to making a responsible decision in any situation and assure its realization
- Technological competence, i.e. readiness to understand instructions, technology descriptions, action algorithms, full adherence to the technology of practical activities; allows students to foster and wisely implement new technologies, think technologically in various life situations
- Readiness for self-education, i.e. an ability to identify issues concerning his/her knowledge and skills when solving new problem, evaluate the need for certain information for his/her activity, conduct the informational search and retrieve information from various sources on any kind of devices; allows altering his/her professional qualification flexibly, self-mastering of knowledge and skills necessary for solving a preset problem.
- Readiness to use informational resources, i.e. an ability to draw reasonable conclusions, use information for planning and conduction of his/her activities; allows student to take responsible decisions based on critically revised information
- Readiness for social interaction, i.e. ability to correlate own aspirations with interests of other people and social groups, interact productively with other members of a group (a team) that is finding a common solution; allows using resources of other people and social institutions for problem solving.
- Communication skills (competences), i.e. readiness to receive necessary information through a dialog, to present and dispute in a civilized way own point of view within a dialog or a public speech based on the acknowledgement of a variety of viewpoints and respectful attitude towards other people's values; allows using the communication resources for problem solving.

When designing an individual learning path, one of the key questions is the efficient organization of the student's self-study activity, since the extracurricular learning activity serves as a logical continuation of the in-class learning and has to be defined by the educational program. This type of activity includes: working with the lecture materials, preparing for workshops, practices and lab classes, performing individual tasks, course works and theses. Its character, contents and scope depends on a particular study course. Such work is conducted under the supervision of a teacher, who gives a task, consults and sets deadlines for its completion. Students' self-study activity that is included in the educational process is performed without the direct involvement of a teacher, but on his assignment and at a specified time period. In this regard, students consciously strive to achieve the aim of the set task. However, in this case, the time input is not regulated by the schedule. Depending on his/her own abilities and efforts student sets the mode and duration of the work that is later monitored by the teacher during in-class learning sessions. Any self-study activity has to be presented externally – in oral, written or electronic forms [4].

In line with the above statements it is worth mentioning that for the successful exploitation of student's individual learning path a thorough revision (remaking) of course's content and learning methods has to be conducted by the teacher. Therefore, while executing an educational program in field of engineering teachers should commit to the following recommendations:

- Forms of self-study activity should be defined according to the study course, its aims and objectives, level of complexity and practical relevance.
- Student's self-study activity has to be executed in line with the personalization of tasks, as well as with the level of proficiency and dispositions of a student.
- Enhancement of student's self-study work efficiency and qualitative modernization of the educational process overall depends on the exploitation of innovation technologies.
- Application of the whole variety of students' self-study forms of organization allows the most efficient stimulation of cognitive activity of students [3].

When developing practice-oriented educational programs it is recommended to introduce the module technology for design and development of the corresponding curriculum. In such case, the curriculum represents a synergy of modules that includes associated courses, practices and other types of educational activity. Each module requires a clear definition of learning outcomes determined by the overall results of educational program's mastering. Module's learning outcomes have to be assessed with use of complying assessment tools that, together with the traditional forms of control, may include interdisciplinary educational projects.

Within the design process of an educational program based on engineering, specific attention should be paid to the design, which include creative application of scientific principles for design and development of facilities, mechanisms, devices, production processes and operations.

Introduction of engineering principles in the educational program permits formation of the following key competences required by modern employers:

- Selection of proper machinery, tools and technological equipment.
- Inspection of the production operations.
- Development of recommendations on its modernization.
- Development of technical sketches of details.
- Development of production technologies for details' production, etc.

Consequently, when developing an innovative educational program in field of engineering it is necessary to take the following actions:

1. Make a synthesis between professional and educational standards' requirements.
2. Structure clearly the descriptions of learning outcomes and fostered competences corresponding with the employers' requirements.
3. Develop educational programs, which, from the one side, are standardized according to the professional requirements, and, from the other side, assure personalization and differentiation of educational process.

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# Contemporary Day Discussions on the Concept of Elite Engineering Education

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**Article is devoted to modernization of domestic system of engineering education. According to the innovative development in higher technical education there exist contradictory problems which have been studied. The role of technical universities in preparation of professional elite – scientifically-engineering and state-administrative is considered. Analysis of transformation processes in a domestic education system is presented. Considerable attention is paid to the methods of shaping a modern engineering outlook.**

**Key words:** engineer, modernisation, higher education, the industry, innovations, professional elite, methodology, formation, the concept, reform.

## Introduction

In modern society the educational market is quite diversified, and Russia has to step in more actively, become more competitive and constantly work on raising its competitiveness that can be, first of all, supported by the modern education. Modern fundamental education is one of the powerful instruments for quality advancement of state management. It should be noted that elite education is always the innovative education. For the development of Russia, for its shoot forward, the core strategic objective is to take a shift towards innovation development path. Modern high-level education is a valuable tool for introduction of innovative approaches to all spheres of economics, production, science, culture, as well as the educational system itself.

In a society that relies on a solid knowledge base, higher education attains a top-priority role in development of countries and the global society overall. As a result, the key roles in such societies are played by people, those who obtain this knowledge, are capable of applying it on practice, and create new knowledge; people, who build up the society's intellectual elite [1, c. 47-51]. Among these society's educational institutions a distinctive place is assigned to the elite education, the main goal of which is the development of deep up-to-date knowledge.

Thus, for instance, Russia has always been known for its engineers; this profession has been a respectable one both in the pre-revolutionary Russia and in the Soviet times. Within the past few years there have been a number of actions implemented in order to support national engineering schools [2, c. 102-104]. National research universities that focus on training nuclear modern technical specialists have been created. Starting from 2006 over 54 billion rubles have been invested targetedly in the development of facilities and resources of engineering departments. The quality of specialists training has been successfully advanced, including training in such critically important specialties as aviation, atomic, automobile industries, metallurgy, power engineering [3, c. 88-91]. It is gratifying that social prestige of the profession is also rising; a career of an engineer is becoming more attractive from the point of its status and material wealth. Large industrial projects that are genuinely interesting for engineers to work in are launched in the country. And it is natural that more and more school students







are keen on mathematics, physics, and chemistry. Leading universities report that a specific tendency for these professions' prestige rising is getting stronger and the number of enrollees is growing. Nowadays, natural sciences are in favor and the selection competition for hard sciences is rising [4, c. 12-14].

Besides, there is a fair-minded demand for changes in the system of engineers' training. It is not only the technological, but rather the overall lifestyle that is changing in the modern conditions; perception of engineering is altering, and the requirements for this profession are growing. Modern engineer is a high level professional worker, who does not only operate complex machinery or design up-to-date equipment and machines, but, as a matter of fact, forms the social realm [5, c. 106-108].

## Fundamental basis for elite engineering HEIs

With an aim to train an intelligent and sophisticated engineer it is necessary to construct the curriculum in a way to have no less than 30% of the total number of hours for the fundamental sciences. Unfortunately, we have a completely opposite tendency. It originates from the fact that number of natural science subjects is, unfortunately, decreasing rapidly both at schools and in universities [6, c.10-12]. Thus, for instance, physics is not a mandatory subject for the Unified State Exam, and even mathematics may be excluded. Our goal is to enlarge the fundamental component of education. And we have good opportunities for this, including engagement of the Russian Academy of Science potential. It is possible today, but it needs to be fortified; and the leading scientists, who work at the Russian Academy of Science, need to work at universities.

The normal workload of faculty members in foreign universities usually does not exceed 300 hours, and the great majority of all teachers is actively involved in research. If we really intend to come to the level of the world leading universities, we need to limit the overall workload of the teachers to the level of 400-450 hours including around 150 hours of lecture time for professors and associate professors [7, c. 171-172]. This is approximately the level of workload that leading universities imply.

It should be noted, the global tendency for humanitarization of education approves itself in Russia as well, where the trend for development of higher education system – reduction of number of technical universities – was accompanied by increase of human science majors, especially those of law and economics (notably even with overlap: in recent years an excess "production" of specialists in these majors took place). Other more general indicators of Russian educational system are in an even worse state. The cutdown of budget allocations for education is accompanied by the brain drain, insufficient quality of mass (non-elite) education, stagnation of such an important development indicator of education as the number of students per thousand people. It is a known fact that budget allocations for education are the investment in the country's future, and the reduction of these allocations is a train wreck waiting to happen. The revival of Russia as a superpower is only possible if education truly becomes one of the key priorities of its social development [8, c. 75-76]. It can be revitalized not by selling its natural gas, oil and other natural resources (which means stealing from our future generations and taking the straight root to transformation into the third world countries), but only by developing those traditions of the great culture, that made invaluable contribution to the development of modern civilization.

Unfortunately, the world-wide tendency for fast growth of HEIs' number and quality of higher education is contrary to the Russian policy for education that has resulted in rough reduction of budget allocations in the 90s. Consequently a vast number of countries have drawn ahead of Russia in this sphere. Back in 60-70s Russia had a leading position in number of students to overall population ratio. Today Russia has been outdriven in this indicator not only by USA, Japan and many European countries, but also by such East Asian countries as South Korea and Taiwan. Reference to the economic difficulties (especially in the context of high prices for energy resources) cannot justify such a shortfall policy for education that lowers the chances of Russia for its economic upturn, for the recovery in the post-crisis period of the XXI century [9, c. 32-34].

As of the moment, undoubtedly, it is not enough to have engineers, who obtain good professional skills in a specific field. It is essential for people, who get employed by enterprises, to understand methods of project management, to know principles of lean production, to comprehend cost management on all stages of the product's lifecycle.

It should be noted that the balance between practical and theoretical knowledge should be 70 to 30 percent. So far worldwide there has not been found a better way to solidify theoretical knowledge than the individual practical activities (for instance, course thesis and course design work) and the internships with mandatory presentation of the work. All these activities contribute to the development of students' system thinking and ability to analyze numerous facts and make proper conclusions.

When comparing the educational systems of the USA and Russia, first of all from the point of the development of the elite education within them, it is worth noting the deep differences of these systems that are connected with historical traditions, mentality, economic and political structures of the countries. It is no doubt that these systems differed the most during the period, when our country was led by the soviet government. American educational system has always been built according to the pluralistic development path, where different educational models have been competing, and where the key role in line with the state educational programs was played by publicly developed programs. Besides, the federal programs had a rather advisory, than prescriptive nature (that seems natural in the context of the private educational institutions' existence), where education was greatly influenced by state and local bodies. In other words, this is a system with high degree of decentralization. An opposite educational system was represented by the soviet system of education, i.e. the unification, ideologization of educational process, dominance of egalitarian approach to the organization of the educational system.

During the post-Soviet era the educational system of Russia has been rapidly moving towards its deideologization: total governmental control is dissolving, educational programs and educational institutes are becoming more diversified, individual and group public interests are being taken into account. Frankly speaking, this is an obvious step towards pluralistic educational model. Thus, we can acknowledge a certain convergence of educational systems of Russia and countries of Western Europe and North America in line with the paradigm of pluralistic educational system [8, c. 74-76]. This is even more noticeable in the context of Russia accepting the Bologna Declaration.

There can be seen a certain shift of Russian models for recruiting the elite – from nomenclative to the pluralistic one (although, as it has been mentioned, there are contra tendencies existing), towards recruiting of elite through different channels, basically, towards a more transparent system of recruiting, that draws it closer to the American and Eastern European systems of elite recruitment. Thus, we can underline the overall shift of different socio-political structures towards pluralistic models reflecting democratic processes in the modern society. These changes can be addressed as a part of the global transition towards the growing role of an individual as a part of social process that reflects the humanization and democratization of the global socio-political development.

However, the existing underrun of the Russian educational system, including the elite education, is intimidating. As has been stated above, the majority of experts in economics and sociology of education justifiably believe that for the sake of accelerated development of the country the most efficient actions are the investment in the "human capital assets", in the fields of education and science (some economists believe that each dollar put into the development of science and education in short term period will turn out to bring in at least 10 dollars). Therefore, it is possible to speak of the poor judgement of those governments that do not enlarge (or even decrease) the expenses on science and education when planning the budget.

Unfortunately, the drastic cutdown of the budget allocations for education and science as part of the "reforms", such as those that took place during the 90s in Russia, led to the catastrophic decrease of the level of education. And in the XXI century, despite the announced priority of the educational system development, its financing is still being far behind from the leading educational systems funding, especially of such in USA, Great Britain, Scandinavian countries, Japan, where education expenditures overrun Russian budgeting not only in the absolute numbers (which can be understood), but in its proportion within country's GDP. This becomes a precondition for future underrun of Russia in this field that may consequently lead to future degradation of our education and science (and this will further result in the degradation of economy and culture). While Russia still has HEIs and scientific school, that have high ratings in the global system of education and science, it is essential to develop a system of education and science in Russia with the advanced growth rate leaning on these schools (and especially on the leading and academic universities).

It is necessary to optimize the number of higher engineering education institutions, excluding the possibility to blur the majors and specialties of the national technical higher education establishments. This optimization process should be in line with the development paths of the regions and the complex integrated structures: the Ministry of Education and Science of the Russian Federation together with the Ministry of Industry and Trade of the Russian Federation and other state executive authorities, corporations. A list of high-tech production and scientific organizations should be created and approved; those organizations that will be obliged to officially employ and pay students for comprehensive annual industrial internships. These measures should correlate to the development tracks of innovative territorial clusters in the regions. The number of individual laboratory and practical activities in HEI should be enlarged; these activities should be conducted on a "simple-to-complex" basis. It is necessary to organize comprehensive annual industrial internships: during the first year – one internship a year; during the latter years – two internships a year (at the beginning and at the end of the year). HEIs, especially the engineering ones, should have in possession up-to-date analytical and technological equipment, since it is the basis for scientific schools' foundation.

It should be pointed out that in the information society knowledge is, first of all, used for the production of the knowledge itself. The optimum management of such society should be based on the effective knowledge use for creation of new knowledge, including the most general knowledge that is focused not on any applied goal, but on the production of new knowledge. That means that it is not a direct answer to the subject's demand, but a solution to a more general problem: how to solve a specific class of problems, where the solution for an applied problem is just a special case of a general theory. At the same time a relative independence of science from the applied goals of the subject, its self-reproduction is noted. Knowledge is the intellectual capital that is distinguished from natural, human, financial resources also by the fact that while transferring it (or selling for a very high price) the creator does not lose this information, he/she fosters and enhances this intellectual capital. Whereas by selling material assets, especially natural resources (they are always limited, usually non-renewable, and very often in deficit) the seller always makes his/her country poorer. The key good in the postindustrial world is the intellectual capital, thus, its creators play the key role as well.

At the present time, a concept of mathematics education is accepted [9, c.23-36], it will allow the development of the basis for mathematics to become the force for other natural science disciplines. However, this may take some time, so, first of all, special attention should be paid to physics and informatics, not with the use of a top-down approach, as, for example, to announce a mandatory Unified State Exam on physics, but by creating a special environment, where the school and the students will be interested in teaching, learning and passing these subjects.

Year by year the number of school graduates, who take the final exam on physics and informatics is growing. Currently this indicator is estimated to be 30%. From the one side, this means that the prestige of engineering profession among school students is growing, from the other side, their self-confidence is rising, and, therefore, the quality of physics and informatics training at schools is advancing [10, c. 34-36]. Currently the laws and regulations allow the foundation of basic university departments at partner enterprises and not just at scientific organizations, as it has been before. These basic departments (their network is already growing) are to become the basis for the internships and realization of new educational programs. Besides the knowledge consumption and skills development, special attention is paid to the formation of soft skills, general and professional competences.

The statement about the connection between science, practice and engineering education is highly important, it is essential for any type of education. And here both types of mechanisms are acceptable: the ones that have been mentioned before and the ones that are provided by the current legislation. No one stands against putting these standards and these educational programs through filters of the employers. This is how it is done in many universities. As well as no one stands against attracting employers to be a part of educational and methodological expert teams, HEI's scientific commissions and state examination boards. This is the right of an HEI, and it should be exercised.

## Conclusion

When discussing the problem of the enhancement of engineering professional training level and the compliance of the acquired knowledge and skills with the requirements from potential employers and the demand from the real economy, it is essential to advance the whole structure of the educational process. It is necessary to head on towards continuous increase of investment into the field of education; this is the main track for the revival of Russia with its great cultural and scientific traditions. There needs to be a selective support of skilled and talented youth that includes the processes of searching and selecting gifted kids, talented girls and boys. These activities will mainly include the already tested competitions – regional and all-Russian olimpiads, awarding grants to the winners and runner-ups for them to be able to enroll at country's technical universities (it especially concerns the support given to the gifted kids, talented youth, who live in outland, in cities and countryside far from cultural centers). This is a vital element of the state policy on elite engineering education. The knowledge-based economy should be the prevailing one in Russia. A specific, if not the central role should be given to the education and science, first of all to the engineering education that has close ties with the knowledge development and training of specialists, who can manage high technologies, apply methodology of information analysis – specialists of very high level of qualification, innovators, who broaden the horizons of the mankind, whose lifestyle is a continuous and rapid development in the context of fast obsolescence of old knowledge, the need for its constant renewal and rethinking, and the need for new approaches, new ideas, new unifying theories. Russian system of education should have a flexible system of process management, where there is no strict centralization, where there should be a strive for balance between state educational programs and regional, local ones. National programs for the development of education should include the control of the academic level of education, level of educational management, pedagogical control focused on the art of teaching, professional control – analysis of HEIs' graduates from the point of the "consumers" requirements, encouragement of different educational forms and methods.

The contents of this article can be useful for a wide range of faculty members and students, the system of vocational professional training, the system of HEI staff development programs, engineering and scientific workers.

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УДК 378.1:004

# Model of Students' Practical Training Processes in Institutions of Higher Professional Education

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

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**The article deals with the model of students' practical training processes, its unit-by-unit description of processes and relationship between them. It forms the basis for subsequent development of a monitoring model.**

**Key words:** process management, resource technological base, the quality and efficiency of education, the rate of rationality, information-analytical system.

**Problem statement.** One of the most relevant trends in the improvement of contemporary education is the development of information and analytical resources (IAR) that reflect its actual status and can be used in management system design [1. p.7-9]. Adequate solutions, management objects and algorithms, for example, quality of student's practical training, allow effective management in the educational process, the major constituent of which is academic-research-production base and, as a consequence, answer the question: "Whether expenditures for practical training justify high quality education of a highly -qualified and competitive engineer?"

IAR are developed on the basis of integrated monitoring. At the preparatory stage it is reasonable to design a model of students' practical training processes to consider in detail the sequence and integrity of the processes in which the problem of IAR development is solved, to evaluate the quality and effectiveness of students' practical training at all learning stages and set management functions [2, p. 10-13; 3, p. 22-25].

**Results analysis.** High quality of professional education is profound fundamental training based on the latest scientific achievements. These two principles have become academic-research-production base, which defines the resource potential of a university and conditions the opportunities of training sessions, research, and development, their results and quality of students' practical training. At present, the development of academic-research-production base is performed through the implementation of high-tech, modern equipment and development of new technologies and forms of training. Both trends form a complex: innovative education system grounded on academic-research-production base, which is appropriate to term a resource technological base (RTB) of education. It is clear that RTB, its state and development, is a crucial factor of HPE quality [4, p. 31-35].

Competence approach is taken as a basis for HPE FSES. Defining the competence functions in training supports the main essence of competence approach – to enhance the practice-oriented training. Therefore, a distinctive feature of the modern HPE development stage is the significant increase of students' practical training. This peculiarity promoted the formation of innovative training systems based on RTB, for instance, resource centers academic-research centers, research-academic clusters, etc. The design of such innovative systems provides a guarantee for high quality learners' practical training [5, p. 114-116].

At the moment, the quality management system (QMS) in universities has been established and certified, which is based on the international quality standards of ISO 9001: 2000. Development and introduction of QMS is focused on initiating institution-economic thinking: if authorities seek to fund educational activities from their funding sources, provide commercial services for training and qualification upgrading, it is necessary to develop a well-functioning management system. Hence, it is important not only to develop university QMS and its certification, but also maintain the system in working conditions, initiate the process of continuous quality improvement (PDCA cycle implementation – Planning, Going, Checking, Acting developed by W.E. Deming). The relations of the Deming cycle stages are possible if there is a complex monitoring and quality assurance system in the university QMS, which assists in performing the adequate managerial functions [6; 7, p. 62-67].

The distinguishing features of new education system management are defined by the fact that it has a complex structure consisting of some subsystems, which interact between each other and other public life spheres. Therefore, principles of management consistency and integrity are the most important ones for education system [8, p. 75-77].

RTB as a university subsystem includes a network of educational laboratories (training, research, production), equipment service center, marketing centers of labour market, equipment, pedagogical technologies, and learning outcome monitoring and management [4, p. 20-21].

In modern conditions education management is, first of all, its development process management. One of the fundamental statements of the standard ISO 9001:2008 – process approach: an institution has to present its activity as a chain of interrelated processes.

The university activity consists of the following basic processes:

- academic;
- research;
- development of research, production, and teaching materials.

Each of the above- mentioned processes includes the processes of authority management, resourcing, processes of production life cycle, measurements, analysis, and improvement. The process performance indicator is reflected through its "overall efficiency". To make management decisions, the most useful information can be obtained via directly measured indicators [2, p. 25-28].

The author of the work [9, p. 96-98] proposes to develop a system of indicators reflecting the relations between expenditures (investments) for training with RTB and quality of competence development at every level of training, which, in its turn, is based on multilevel monitoring and quality and effectiveness assessment of student practical training. The indicators system of corresponding training level can be referred to as "effectiveness". It includes directly measured IAR intended for management system development for student practical training and is focused on solving the formation problem of innovative education system based on RTB, which would provide high quality engineering graduate practical training in rational investments into its design.

**Model of student practical training processes.** Studies in state and development [4, 5] of HPE have allowed formulating the ideas, with the support on which the conceptual model of student practical training processes is developed using RTB.

1. A university produces "goods", which include graduates, as well as research, production, and teaching products; university educational activity has much in common with any engineering process with the only difference- the duration of training engineering process, which is 4–6 years.

2. According to Selezneva N.A. [10, p. 17]:

- Quality of higher educated specialist training (quality of higher education in a narrow sense) is a balanced consistency of highly educated specialist training (both results and process) to the diverse demands (state, society, person), targets, requirements, norms, standards";
- Quality of educational processes is defined by the quality of curricula and their content, potential of teaching staff and entrants, teaching methods, resources (information, teaching, physical).

The conceptual model of student practical training processes using RTB is shown in Fig. 1.

**Model description.** The presented model was developed on the basis of requirements of GOST R ISO 9001:2008 standards and corresponds to the traditional process model of PDCA cycle [6, 7]. Let us present unit-by-unit description of the model processes and show the relation character among the processes.

Users are university authorities and the teaching staff. They define the requirements for resources, quality and effectiveness of a product (**unit 1**). In current research the product is a student of definite major. The initial data for product design are standards of federal and industry levels, university standards and QMS, as well as resources (human, physical, information, etc.). University QMS is to include the mechanisms of consumers' demand and expectation monitoring and provide the development of products of required quality. Hence, users' requirements are to correspond to the demands and expectations of products consumers. Users' demands form the basis for product design and production.

At the design stage (**unit 2**) users' demands presented in consumer's terms are transformed into product's informative characteristics: engineering, ergonomic, cost and others, setting the qualitative values for parameters. Informative characteristics define the product's designed characteristics (**unit 3**). The designed characteristics serve as a basis for the development of measured product characteristics at monitoring. Information on designed characteristics is delivered to **unit 15**, where the inconsistencies between designed and measured characteristics are revealed.

Product life cycle processes are a set of actions which are necessary to take in obtaining products of designed quality and performance. The product life cycle processes include: arrangement process (**unit 5**), educational process (**unit 6**), resource supply process (**units 7, 8**). In this case, the basic one is educational process, but the other two are supplementary processes. Educational process consists of three subprocesses: academic, research, and production (internship at enterprises). These processes follow each other over the whole study period:

Arrangement activity is regulated by normative-legislative framework of federal, industrial, university levels, QMS documents (**unit 4**), which defines the product quality at the design stage. Its main purpose is to improve the arrangement of academic process and teaching activity in university.

Resource supply consists of a set of human, physical, and information resources. University has to guarantee the availability of adequate resource environment of high quality product (ISO 9001:2008).

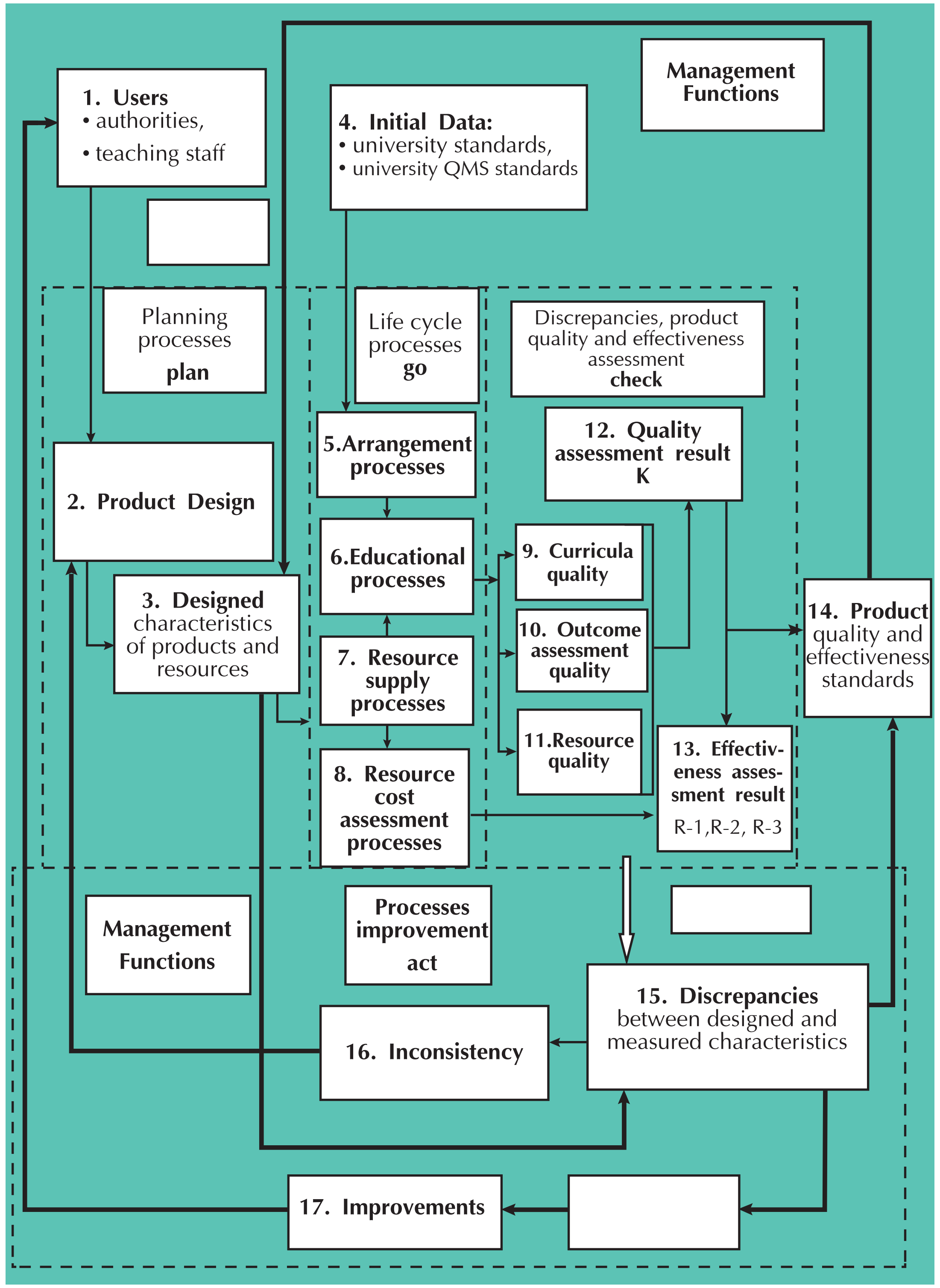
Unit 8 is used to evaluate the cost of resources for students' practical training. Information comes to **unit 13** to calculate the effectiveness of student practical training at every educational level.

The quality of educational process is preferable to be presented as a quality with the following constituents:

- curricula and their content (**unit 9**);
- teaching aids for outcome assessment (**unit 10**);
- resources (**unit 11**).

The quality criteria of curricula concerning practical training: informative education, technical support. The quality criteria of resources supply are: staff, resource, information, teaching, arrangement.

**Fig.1. Model of student practical training processes (R-1, R-2, R-3 – indicators of effectiveness in academic, research, and production RTB)**






The quality criteria of methodical aid for learning outcomes assessment are: validity, test reliability; techniques of credit-test, exam, and interview task development, university rating system, etc.

The quality of educational process components defines the results of quality assessment and practical training assessment effectiveness **(units 12, 13)**, as well as their compliance with quality requirements **(unit 14)**.

Quality standards **(unit 14)** is a developed and registered system of requirements for product quality and effectiveness (as an outcome, as a process, as a system, in general) corresponding to the identified needs. Norms are developed on the basis of previous monitoring measurements and results of assessment and current surveys. Deviations from the standards are registered by the management functions for designed characteristics to be corrected and/or to eliminate deviations [11, p. 63].

In **unit 16** the information on inconsistencies revealed in **unit 15** is accumulated. Management functions are sent to **unit 2** for analysis and decision taking on product design.

Information on effectiveness indicator, which is minimal of the three (R-1, R-2, R-3), comes to **unit 17**. The minimal value of effectiveness indicator shows the fact that there is low effectiveness of student practical training at the given level. Management function is directed to a user to make decision for product improvement.

## Conclusion.

In conclusion, it should be underlined the characteristic features of the developed model of student practical training processes.

Firstly, process objects correspond to management objects. In our case, all objects of the processes: users, design process, life-cycle processes have management functions in the form of which the process results are used.

Secondly, it corresponds to the model of continuous improvement process principle, which coincides with the new concept of process – "is a set of interrelated and interacted types of activity transforming inputs into outputs. In an institution, processes are planned and performed in regulated conditions to add the value" [6].

Suggested and described model of student practical training processes can serve as a basis for the development of integrated monitoring model.

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UDC 621.81

# Multimedia Lectures on Discipline "Machine Parts"


**Volgograd State Technical University**
**M.M. Matlin, I.M. Shandybina, M.V. Topilin, A.N. Goncharenko**



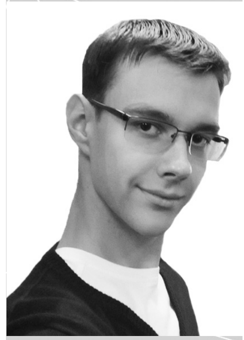
**The method of development and implementation of the multimedia lecture course on discipline «Machine Parts» into the learning process is considered in the article.**



**Key words:** multimedia lectures, мachines elements, computer technology, learning process.


M.M. Matlin

I.M. Shandybina



M.V. Topilin

A.N. Goncharenko

Over many years Machine Parts and Pick-and-Place Devices Department of Volgograd State Technical University has been developing and implementing computer technologies [1] into the academic activity in three main areas:

1) development of virtual laboratory works for computer classes;

2) design of techniques and special methodical support for testing in the course «Machine parts» performed in the platform «Moodle»;

3) development of multimedia lectures.

The multimedia lectures were based on the authors' series of lectures on the course «Machine parts and bases of design» [2, 3] initially amounted 51 hours. The first version of multimedia lectures started at the department as soon as 2010. Enormous preparatory work had preceded the lectures [4].

Firstly, it was necessary to systematize and structure the content of lectures. As our experience showed, the most suitable form of course presentation is its modular framework. To arrange the modules' interaction and manage them, a flexible set of hyperlinks was developed. It made the multimedia lectures universal and diverse. The universality of the given course consists of its multimedia use by the students trained in different specialties and majors. In this case, the main content of lectures remained unchanged, but specific feature of each major was included in definite modules, which were referred to by the hyperlinks.

For example, lectures for the students studying the major 241 000.62 «Energy- and resource efficient processes in chemical engineering, petrochemicals, and biotechnology», and referring to the necessary hyperlink, one can show in the screen the slides demonstrating parts and components of machine and devices for chemical production. Such an approach is particular useful for a lecturer delivering lectures for students learning different curricula in the same term. Moreover, the hyperlink system allows the amount of hours to be changed from short course of 8 lecture hours (for part-time students) to 51 hours.

Secondly, a large amount of photo- and video aids was required to make lectures visual. Not only lecturers, but also students of different specialties and majors were involved in collection and preparation of such materials. As a result, the department collected resource of visual aids including more than 300 photos and videos. To design them, the outdoor photos and videos of different machines, parts, components, and their failures were made; methods of computer graphics, animation, Internet were used.

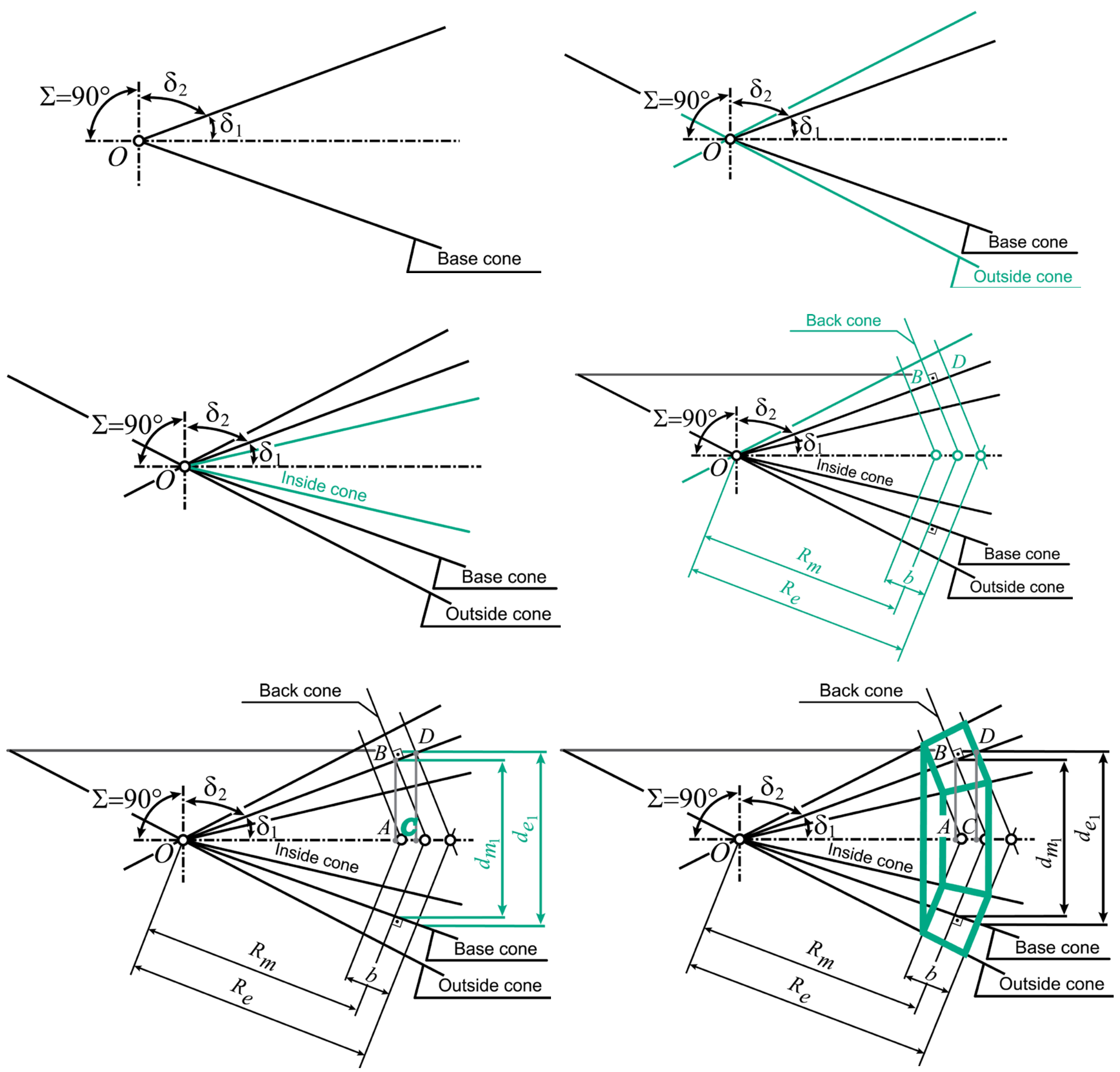
Application of computer technologies in development of multimedia lectures not only provided modern attractive design, but also made possible to perform the incremental construction of complex schemes, drawings, and formulas (Fig. 1). In addition, colour parameter synchronization in the formulas, schemes, and comments made it easier for students to understand the lecture.

At present, every multimedia lecture includes large systemized material and teaching aids for its presentation in the form of slides in different course sections [5].

To assess how useful the multimedia lectures were for students, we conducted mini sociological survey with the subsequent processing of the data obtained.

In total, 100 students took part in the survey including 49 boys and 51 girls. The 3d and 4th year-students' groups of Chemical-engineering, Electronics and Computer Science Vehicle and Weapon Systems Departments were chosen for the survey. They had listened to the course of multimedia lectures in the subject «Machine parts and bases of design»

**Fig.1 Stages of complex drawing design**






previous academic year. The respondents were asked to answer five questions.

The survey showed that multimedia lectures were preferred by 53% respondents, out of which 31% boys and 22% girls; traditional form of lectures was chosen by 43%, of which 16% boys and 27% girls, and 4% could not answer the question (Fig. 2).

As the main advantage of multimedia lectures the respondents pointed out their visibility, 46% voted for it, the second place was given to simplicity in perception (29%), then comes information capacity 10%. 9% did not see any advantages and 6% suggested their own options. Among the students' suggestions were possibility to take photo of slide, to show video, and to choose the speed of lecture delivery.

Most part of the respondents regarded multimedia lectures as a more convenient form for lecture perception with 57% being voted for them, 41% giving their preference to traditional form and 2% having no definite opinion.

Answering the question «Which type of lectures allows learning more amount of information?» the opinions were divided, 32% of the interviewed students gave their preferences to multimedia lectures, the same number of respondents thought that both types of lectures allowed learning the same amount of information, 26% of respondents voted for traditional form of lecture; 10% could not answer the question.

Use of photo, video, and audio aids in the lecture was considered useful by 90% of respondents.

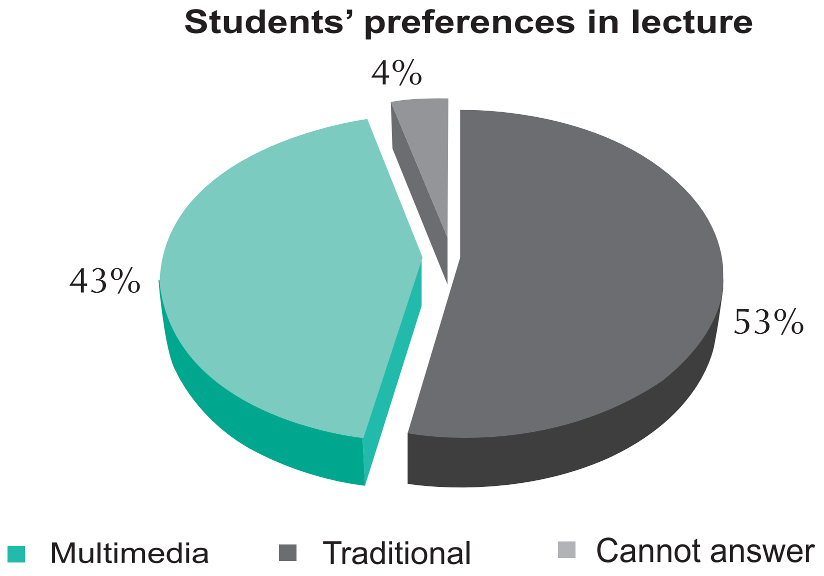
From the students' point of view, multimedia lectures have a number of advantages in comparison with traditional ones.

In their opinion, the most significant advantage is informative layout in the slide. It sufficiently simplifies note making and understanding a lecture.

As for figures and schemes, traditional lectures yield multimedia ones as well.

Possibility to use video in addition to lectures allows a student to develop a visual image in his mind that improves the process of learning information, in future helps to write laboratory reports and prepare for exams. Besides, when commenting the schemes in the course of multimedia

**Fig. 2. Results of students' opinion survey**



lectures, stage-by-stage introduction of parameters enhances understanding and memorizing information in comparison with notes on the board, where sometimes it is impossible to place a large amount of comments without erasing some parts of figure.

In addition to the mentioned above, one can note that the slide design itself draws students' attention to the key points of multimedia lecture by means of highlighting the text in colour different from the colour of the main text or framing «the main idea».

Thus, our experience in multimedia lectures allows for the following conclusions. Multimedia approach to lectures provides significantly their visibility. Visualization, brightness, dynamics of figures performed with multimedia computer tools help to explain the most complicated phenomena and processes to learners. Students better understand complicated information requiring visual support, moreover, multimedia lectures shorten the time of learning information and improve the efficiency of academic activity in general.

Some sections of multimedia lectures were included in programs of different transmission design. The program of belt transmission design in its hauling capacity was given the protection [6].

Multimedia lectures obtained four-year approval, correction, and are completely used in academic process at the department of «MP and PPD», VolgSTU.

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# Scientific Knowledge Concept: Case Study Technology and Its Practical-Oriented Application

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**Shaping the competences of a Master-student within the framework of Federal Education Code new generation of Higher Professional Education is implemented through an innovative methodology, i.e. case study (portfolio). This methodology is coupled with such aspects as self-control, cooperativeness and, especially, teamwork. This article is a continuation of previously published papers [3, 4, 5].**

**Key words:** scientific knowledge concept, shaping Master-student competences, innovation in engineering education.

New generation programs of Federal Education Code (FEC) oriented at the competency-based approach are focused on the development of those tools involved in the shaping of Master-student competences, as well as innovative methodological documentation. Such a discipline as "Philosophy and Logics" for Master-students of different engineering domains has been introduced in Tyumen State Oil-Gas University. The above-mentioned problem is solved by the application of innovative teaching methods in combination with designed integrated courseware, which, in its turn, are being tried and tested within the framework of the Master-student programs.

Besides, the existing traditional tools, certified teaching methods, management and monitoring organization procedures, newly updated methods and techniques have also been introduced. The proposed learning-teaching package includes course schedule, lecture and practicum plans, and self-instruction guidelines – for tutorials and self-directed learning. The guidelines include a set of assignments, forms and possible procedures to determine the qualitative and quantitative parameters for learning outcomes.

The methodological recommendations in defining the quality evaluation of the learning outcomes are as follows: shaping Master-student competences, i.e. the readiness (including motivation and personal qualities) to demonstrate one's abilities (knowledge, skills, experience) in future professional and research activities under the existing conditions of today's national science and domestic economy. Learning outcomes are determined by the acquired competency qualifications of a Master-student both after the completion of a course and education program (specialization). Competency qualification is expressed in a score-system integrated as a learning table-matrix, as well as final assessment as a credit test.

Learning outcome elements are those independent abilities (knowledge, skills, and experience) which could enhance a Master-student's performance in research of this or that topic, field or specialization and further his/her research results in step-by-step practical application.

Design goals are to investigate the common characteristics of scientific knowledge in the domain of logics oriented at science and technical-engineering methods; and to explain their interdisciplinary and cross-disciplinary interaction. The discipline "Philosophy and Logics" is included in the general courses of Humanities and Social Science-Economics. The objectives of this discipline are as follows:

- to develop an interest in background knowledge;
- to enhance the need for critical analysis of today's state-of-the-art;
- to understand the concept of integrated global scientific-legislative proceedings and its diversity in conditions of economic and cultural globalization.

This course is an introduction to scientific (i.e. engineering) knowledge methodology relevant to the Master-student major. The basic tasks are:

- to promote the development of a system-based conception of scientific knowledge, step-by-step research methods and procedures, shaping and developing skills in independent research;
- to consider science as a specific activity oriented at the generation of new knowledge;
- to analyze the development patterns of scientific knowledge, accumulation and alteration of research elements such as subject, tools, research methods, aspects of scientific communication, types of disintegrated and cooperative research;
- to identify and update the role of scientific knowledge in the development of the human society and industrial production under today's conditions.

Learning outcomes state that the Master-student should internalize:

- scientific-philosophic and philosophic methodologies, fundamental base and universal scientific knowledge to further deep analysis and understanding of the existing processes within contemporary science and R&D management;
- major principles and methods, structure and topics of contemporary scientific knowledge;
- specific features of formatting research papers (annotation, review, abstract, article, master thesis, monograph) and mechanism of personal participation in the research itself.

Based on above-mentioned factors the Master-student should:

- employ developed skills in unbiased and multi-dimensional assessment of focus areas and schools in the sphere of professional activities;
- identify the scientific, theoretical, methodological, and practical aspects of studied issues;
- logically formulate, present and reasonably advance one's personal representation of discussed research problems;
- actively participate in scientific dialogues and discussion, correctly ask and answer questions;
- actively assimilate the material, reinforce practical skills and have a deep understanding;
- study independently, organize procedures in self-study groups and team work;
- perform independent research on this or that research specialization (annotation, note-taking, abstracting, formulating thesis and articles).

The humanitarian component of the engineering education provides such opportunities for a Master-student as:

- "distinctly to define the structure of contemporary engineering and technical knowledge, be able to analyze the socially-important problems and processes, apply creativity approaches in different professional activity domains;
- possess the principles of thinking, know its laws and be able to apply them in research, analytical, project, engineering, organization, performance, pedagogical activities;
- have skills in oral and written communication to enhance a high-level research and pedagogical activity level;
- be able to acquire new professional knowledge by applying updated learning technology" [1, p. 3-4].





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The discipline "Philosophy and Logics" involves the Master-student personal development in the process of which one would be prepared for independent research; development of an algorithm-related system of practical skills based on topic selection, relevancy, delimitation of the subject, topic, target and goals, problems, analysis of the level of theoretical and methodological development issue, planning and scheduling research, referencing, writing annotations, reviews, reports and notes, selecting key words, compiling glossaries; procedures in testing research results, preparing written tasks, theses, articles, references based on the standard reference system according to GOST 7.1-2003 [2].

Different methods in shaping competences are combined in accordance with such factors as the level of Master student qualification and previous learning level. They include:

- simulation methods: merging Master-student research competences with future professional activity conditions through situation tasks based on contextual learning, which, in its turn, provides integrated assessment of several attributes simultaneously;
- integrated control methods developing self-assessment and peer assessment focused on the ability to conduct behavior corrective actions and improve one's achievements; combination of group and peer assessment methods (peer consultations and reviews; annotations of essays, projects, research phases, pair/group self-assessment), including systems of table and card material;
- feedback methods: team, group, mutual, and self-diagnostics of the creativity level in problem-solving;
- corrective methods: developing internalization skills of independent expert assessment and conducting "error correction" including expert analysis of potential employers, professional associations, and enterprises;
- innovative methods: application of modern support - based IT, systems and programs providing systematic and independent control of learning outcomes, on-time learning trajectory correction (EDUCON system, electronic resource – e-Library.ru).

Evaluation of research results show that the proposed innovative approach tasks and objectives being implemented into the engineering education foster: transition from individual competences to the development of integrated (complex) and interdisciplinary competences; transition from the passive "estimator" in the assessment process to the active "participant" in dialogues and polylogues, and, consequently, formulating the answer content or shaping a skill; changing the nature of the results: from single 4- level grading as one unit (1,2,3 assessment + test) to complex grading (designing case-study/portfolio, including individual Master-student research package relevant to practicum topics).

Assessment of the discipline include: formative assessment, midterm assessment (credit). The Master-student is informed about the specific types and procedures of formative assessment and midterm assessment throughout the first training month, and this information is duplicated in EDUCON system applied in Tyumen State Oil-Gas University [3].

An important component of the learning-teaching package is the monitoring-test materials and assessment tools. Readiness for future research activities in preparing the Master-degree thesis is evaluated by an integrated (complex) assessment system algorithm, including individual work (i.e. essays, glossary, annotations, notes, reviews, references, bibliographical descriptions, articles indexed by RF Higher Attestation Commission, presentations) and step-by-step execution of the research itself, structured according to the requirements (title page, contents, introduction, theoretical section, practical section, conclusion, references, appendices).

To shape the Master-student competences, the assessment tools are integrated into the innovative methods and on-line tools (peer assessment, teamwork, role games, credited and expert assessment, case-study annotation combined with traditional assessment tools (oral exams, tests, essays, glossary, written examinations), as well as assessment-measurement materials (electronic-form tests, homework, interviews, electronic-class).

The obtained learning results involve a complex of competences, knowledge, skills and experience in research activities, further practical research application to selected Master-student problem-topic. These integrated professional and universal competences are that complex which a Master-student should possess after course completion (self-instruction, ability to present with relevant explanations).

Structure-matrix competences (extract from Federal Education Code / FEC) with detailed description of the generalized and specific competences in accordance with the Federal Education Code generation 3+ is depicted in Table 1.

The number of required presentations to be evaluated is about 3-7 for each class, therefore, all in all, 18 module cases. The grading system includes from 3 to 7+5 case studies; the minimum credits (score points) for a term-54 (at 51), maximum-126 (credit mark = 100). The Master-student should know the principles and methods of research information, algorithms and research stages; be able to perform intellectual operations with scientific information focused on acquisition, selection, presentation, comprehension, interpretation, comparison, operation, correlation, analysis, evaluation, systematization, classification, synthesis, generalization, abstraction, verification-simulation, inference; writing annotations, reviews, lecture-notes, abstracts, articles; organizing key research steps and components of Master degree paper.

Mid-term assessment demonstrating the case-study method results were published in the Conference proceedings of Tomsk State University, within the framework of the Russian Association of Engineering Education [4, 5].

Thus, the innovative integrated application of the case-study method (portfolio) interlinked with organized self-control, cooperativeness and teamwork exhibits practical-oriented results. In this case, engineering education in Russian universities is advancing towards the existing international standards.

**Table 1. Structure-matrix of competences**

| Generalized/ specific competences | Index (FEC) | Competences (FEC) |
|---|---|---|
| Ability to understand the concept and sense of information in the today's society development | CC–1 | Analyze, identify, understand information and undertake problem identification, formulation, and solution |
| | CC-7 | Improve personal and organizational performance and be able to detect and adapt to changing conditions; obtain new knowledge in technology, engineering, mathematics, sciences, humanitarian, and social studies |
| | CC-10 | Apply an understanding of many economic, social and cultural issues in the consequent social, business, and engineering decisions |
| Ability to work in a team | CC-3 | Collaborate in teams to accomplish a common goal by integrating personal initiative and group cooperation |

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# Competency-Based Approach to Developing Educational Standard for Master's Program "Standardizatin and Metrology" at Northern (Arctic) Federal University n.a. M.V. Lomonosov (NArFU)

Northern (Arctic) Federal University n.a. M.V. Lomonosov (NArFU)
***T.M. Vladimirova, S.I. Tret'yakov***

**The article presents the experience in developing educational standard for master's programs in standardization, metrology, and certification. Being developed in line with international practice, the standard extends the scope of professional activities, supplements cultural and professional competences with regard to ecological, economic and ethnic peculiarities of the Russian Arctic zone.**

**Key words:** educational standard, competency-based approach, competence level, competences, master student's professional activity, educational technologies.

The Russian system of Higher Education is currently undergoing enormous changes due to the new requirements imposed by the labor market. To be more precise, employers are searching for the employees who have a wide range of knowledge and are able to adapt to the ever-changing workplace and make independent decisions. Therefore, upon completion, graduates should acquire practical knowledge and a variety of job-related skills.

At the same time, it should be noted that lecture classes prevail over practical ones in the Russian system of Higher Education. The problem arises from the "theoretical character" of the disciplines being taught, lack of active learning and teaching methods [1, 371-372]. Therefore, to meet the modern requirements of the labor market and be ready to train the graduates who are capable of adjusting to labor market demands, it is essential to revise the process of education by introducing the competency-based approach.

Leading Russian universities have been given the right to develop their own educational standards, i.e. university educational standard (UES). Being adjusted to the Federal State Educational Standards (FSES) of Higher Professional Education, these standards allow universities to ensure high education quality in accordance with international requirements. Since there is internationally recognized practice to estimate the quality of education by independent professional accreditation agencies, it is required to meet not only FSES of Higher Professional Education, but also accreditation agency requirements.

The mission of Northern (Arctic) Federal University (NArFU) is to provide a high-quality graduate training, as well as innovative scientific solutions in support of geopolitical and economic interests of Russia in the Arctic region by developing the system of continuous professional education, which integrates science and industry and incorporates the strategic partnership with consumers.

Since 1996, NArFU has successfully trained engineers in "Metrology and Metrological Support" and "Standardization and Certification", as well as engineer-managers in "Quality Management". The graduates of the university are much in-demand not just in the Arkhangelsk region but in the other regions of the Russian Federation, especially in its North-Western part. As the Arctic region is intensively being developed, there







is an urgent need for highly-qualified specialists in standardization, metrology and certification.

Master program should be developed with regard to the up-to-date achievements in standardization, metrology, and certification. In addition, it should be in compliance with NArFU priority objectives and the 2010-2020 development plan.

Standardization, metrology, and certification are among the most important conditions for successful development of the university, particularly:

- high-tech production and industries;
- development of Russian European North and Arctic infrastructure;
- complex use of bio resources;
- development of northern (polar) medicine and public health service;
- environmental protection;
- development of social and humanitarian spheres of Russian European North and the Arctic.

When developing UES for education programs "Standardization and Metrology", the focus was made on the urgent market demands within the Arkhangelsk region and Northwestern Federal District, NArFU development priorities, interests of the Russian Federation in the Arctic, recent trends in European education and primary objectives of Russian education policy. UES is intended not only to promote the use of innovative teaching and learning methods, but also to provide such education programs that would compete at the international level. The main purpose of UES is to provide master's degree program in Standardization, Metrology, and Certification which aims to train graduates with such competences and skills that would help them to handle multiple tasks independently and find the solution how to enhance the quality of products and services provided by the enterprises of different legal forms.

In the course of UES development, the analysis of international experience in educational standard design was carried out. Therefore, we have considered the following documents, regulations, and standards: requirements and recommendations provided by the International Engineering Alliance "Graduate Attributes and Professional Competencies" dated 21 June 2013; the structure and nomenclature of bachelors/masters degree programs, as well as specialist's programs offered within the Bologna Process; requirements imposed to engineers by Engineers Mobility Forum (EMF), APEC Engineer Register, Fédération Européenne d'Associations Nationales d'Ingénieurs (FEANI); international criteria for engineering degree program accreditation, i.e. Washington Accord (WA), EUR-ACE Framework Standards for Accreditation of Engineering Programmes (EUR-ACE), including the criteria for public professional accreditation of engineering education programs provided by Association for Engineering Education of Russia (AEER); Standards and Guidelines for Quality Assurance in the European Higher Education Area [2, p. 26]. In addition, UES has been developed on the basis of outcome-based approach applied not only in educational standard design, but also in education quality assessment; European Credit Transfer and Accumulation System (ECTS); the rating system used to measure the achievement of the learning outcomes; asynchronous learning characterized by students working independently (Learning VS Teaching); student-centered teaching techniques. It is worth noting that the developed educational standard is in compliance with the international standard ISO 9001:2008 (IWA 2:2007) intended to manage educational processes in higher educational organizations within the quality management ISO/IWA 2:2007 [3, p. 10-15].

The developed UES is aimed at resolving the following tasks:

- to expand the field of master students' professional activity by teaching them how to certify and declare products, works, and services in practice;

- to revise the competences in quality assessment and compliance certification with regard to FSES of Higher Professional Education and the recent changes in the legislative system of the Russian Federation and foreign countries;
- to define environmental, ethnic, economic, and other characteristics of products, works, and services provided under northern (Arctic) conditions in the process of standardization, certification, and metrology;
- to introduce module-based curriculum.

The basic difference between UES and FSES lies in the fact that the professional activity of the master students has been significantly changed in comparison with FSES. To be more precise, cultural and professional competences have been expanded. The cultural competences have been transformed to the cultural meta-competences of personal and professional development (CC-P), communicative competences, the competence of thinking principles and information culture (CC-I), and systems thinking competences (CC-S).

The competence of thinking principles involves the ability to analyze, synthesize, compare, contrast, and integrate data. It also includes the ability to think critically and solve problems within interdisciplinary framework (CC-I.1).

The communicative competence is the ability to use the language (native or foreign) correctly in resolving tasks in professional, educational, and scientific activities (CC-I.2).

The information culture involves the knowledge in contemporary information and bibliographic culture, which can be applied in resolving complex tasks in professional, educational, and scientific activities by using information and communication technologies (CC-I.3).

The social responsibility is the ability of students to assume social, economic, and environmental responsibility in their future professional and scientific career. It is the ability to observe professional and scientific ethical standards, as well as to assume responsibility for decision-making and assume extra responsibilities during emergencies (CC-P.1).

Personal development competence involves initiativity, creativity, self-awareness, result orientation and focus on success achievement in all spheres of professional activities. It also involves the commitment to life-long practice toward self-development (CC-P.2).

The project management competence is related to ability to manage projects within different spheres of professional activity (CC-S.1).

The competence to apply theoretical data includes the ability to use the acquired knowledge and skills in practice for profession-related problem solving (CC-S.2).

The competence in science refers to the ability to analyze and apply new methods of research, change the research area within the professional activity. It also refers to the ability to independently conceive, formulate, and conduct research, as well as to implement innovations within the professional activity (CC-S.3).

The professional competences have been expanded by a number of special professional competences (SPC). In accordance with UES, a graduate must acquire the following SPC:

- demonstrate high level of knowledge in metrology, standardization, quality assessment and compliance certification, up-to-date theories, interpretations, methods, and technologies (SPC-1);
- be able to analyze and interpret innovations in theory and practice, demonstrate enough competence in independent research, and be able to interpret results at high level (SPC-2);
- demonstrate the willingness and ability to make a significant and original contribution to metrology, standardization, and compliance certification, as well as enough knowledge and skills for dissertation and thesis writing (SPC-3);
- demonstrate original thinking and apply creative approach to handling practical tasks in metrology, standardization, and certification (SPC-4);
- be able to identify and analyze the requirements to the subjects of standardization, metrology, and certification, as well as to complete detailed technical enquiries (SPC-5);
- be able to integrate possible solutions of a problem or identify approaches to developing a project in standardization, metrology, and certification (SPC-6);
- demonstrate the ability to evaluate the approaches to the quality requirements for products, works, and services and predict the consequences if products and services do not meet the requirements (SPC-7);
- be able to formulate and resolve the tasks in metrology, standardization, and certification by using contemporary information and communication technologies (SPC-8);
- be able to document the processes of measurement system development at all stages of lifecycle (SPC -9);
- be capable of using technological and functional standards, contemporary models and methods of quality and safety assessment in measurement tool design and testing (SPC -10);
- demonstrate the ability to inspect organizations, reveal the metrology needs of consumers, develop the requirements to measurement system, participate in application and information process reengineering (SPC -11);
- demonstrate the willingness to participate in measurement system implementation, testing, and adjustment (SPC -12).

Besides, in accordance with labor market demands, the workload (hours/credits) of definite program cycles has been changed. Particularly, the workload (hours/credits) of the professional cycle has been increased due to a slight reduction in Basic Sciences cycle. It is possible now to deliver not only certain courses, but also the entire education program in a foreign language.

To provide student academic mobility, the credit-rating score has been attributed to each program course (module). This allows evaluating the level of performance that students have achieved studying at different universities.

During the classes and research works, it is recommended to apply the following educational technologies: systematization and visualization of knowledge (lecture-visualization, tests); information and communication technologies to shape and develop interpersonal and professional communication; interactive teaching methods (seminar-discussion); case-study; internet resources and distant information technologies.

The qualification of the faculty members, lab facilities and vast experience in organizing student research work guarantee high quality of master students training. NArFU ensures fulfilment of all the requirements in the implementation of the master program in terms of required facilities, lab equipment (availability of the facilities is currently 80-90%), and library resources for each education program course.

The developed UES significantly expands the field of master students' professional activity since it provides students not only with theoretical knowledge in standardization and metrology but also with practical skills and attributes. These spheres of professional activity are associated with a consumer of products, works, and services as they directly ensure consumers' safety and represent the final stage in quality assessment of products, works, and services. The sphere of assessment and compliance certification has been significantly changed in terms of laws and regulations. Therefore, unlike



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FSES, the developed UES which is aimed at developing required competences in metrology and certification is of significant practical value.

Moreover, within the framework of university development plan implementation and the Arctic cluster orientation, the UES makes it possible to identify quality features of the products offered by the northern enterprises with due regard to environmental, ethnic, economic, and other characteristics of northern (Arctic) region. This allows graduates to carry out essential comparative analysis of the certification criteria used in the Arctic countries and national certification systems paying special attention to environmental issues.

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UDC 378

# Curriculum Design in Engineering Education and the Role of Partnerships

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**Engineering schools have to be aware of three important levels of profile analyzing to guarantee the employability of their graduates: The local market needs in skills, the companies needs in human resources technically, the international openness and importance of partnerships and patronage activities. At Esprit, these three points are considered as key-metrics to design the curriculum in engineering education.**

**Key words:** teaching, learning, design, curriculum, engineering, assessment, market needs.

**1. Introduction.** When it is about seeking what skills fit the new jobs required in every country, it's a whole ecosystem behind that, we have to review and study deeply. We cannot mention the market needs in skills, soft and technical ones, without talking about its needs in human resources. Do the companies require specific technical competences, certified engineers, specialists, excellent products sellers... These are the questions the engineers' schools boards ask frequently. Companies' needs in engineers doesn't only concern the local market but the international one too. We will try to explain how these three components are the basics to design a flexible curriculum in engineering education.

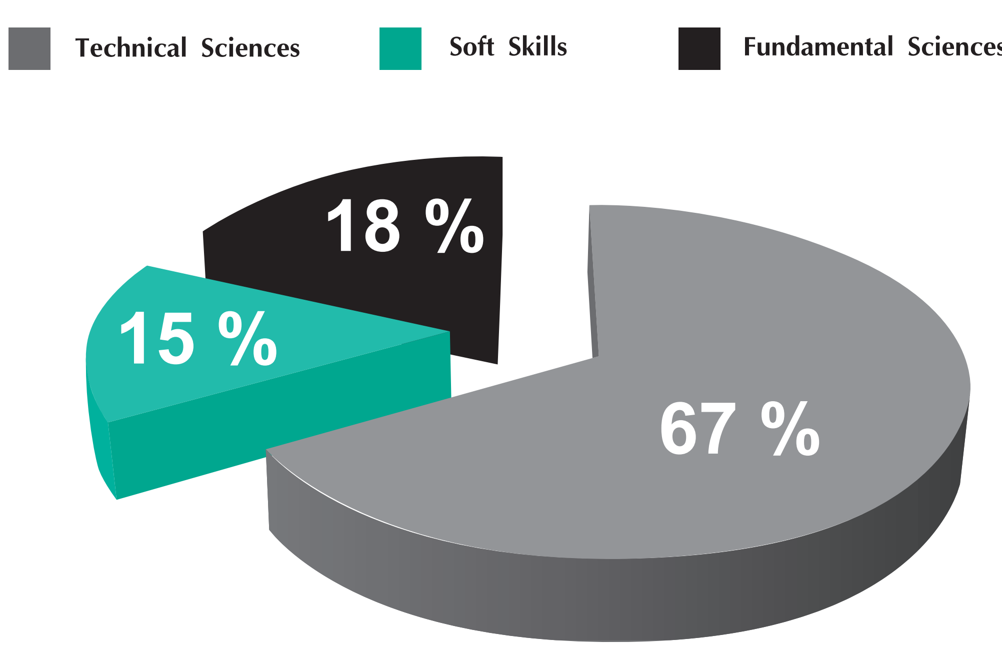
**2. Local market need.** What enterprises managers seek when they want to hire engineers vary from a period to another depending on the economic and political status of the country. Which fields are more important than the others and in which competences we have a lack in are the most important ways of measuring how to grow the company. Let's take for example the IT domain, simply, we can say that as it is empowering every field and always useful, it never dies as an important tool to make services more and more automatic and faster. For the case of Esprit, the best private engineering school in Tunisia, we don't only reform the learning curriculum but the whole university environment to let each entity play its role to constitute this mosaic of ecosystem to keep leading and graduating the best of Tunisian engineers among public and private universities. In fact, we learn a lot on the study of the existing solutions in the local market to inspire teachers choosing the best case-studies to guide students in every level during their engineering studies to be able to develop in their own ability for solving problems and here we can talk about the Problem Based Learning (PBL) concept which is the basic and most important step in designing the curriculum by adopting the active pedagogy. We mean by this way of teaching that students, by time, become able to detect the specific needs technicality of the enterprises in skills that can contribute in developing solutions that can ameliorate the entire economical chain in every industrial domain. So if we prepare engineering students think problem-solution, we'll obtain a very constructive way of thinking and operating in the professional market. At Esprit, and since the 1st year of studying, we push the new generation to think differently by bringing innovative ideas and pitching them in front of experts in entrepreneurship. So we don't prepare them only to be engineers who will look for a job but also to have entrepreneurial spirit where the target becomes creating jobs. ESPRIT has reformed its curriculum by adopting a teaching strategy mostly entrepreneurship-driven. This approach has led the university to fit with the international standards [2] in the term of teaching soft skills like management and marketing using active pedagogy while respecting the number of credits (15% of the curriculum) [Fig.1] required by French CTI (Commission des Titres d'Ingйnieurs) which allowed ESPRIT to become officially accredited by EURACE last year (June 2014) [3].

The launch of an academic incubator is the most important proof that Esprit is working continuously on designing the whole university environment and not only the curriculum. This incubator select, in a collaboration with the engineering school board, the best of the best of project ideas owners with ready business plans to help them by mentoring them till the creation of their start-ups.

**3. Companies' needs.** To prepare good profiles for good jobs and despite the good percentage of its working Alumni [Fig. 2], 72% of its graduates are active in medium and big enterprises [3], Esprit has a Learning Factory that the students can integrate during the last year of their studies to do their capstones' internships by developing their end of year projects from the design level to the test and validation of the solution.

This Learning-Factory is just near the campus and composed by 12 partners companies of the engineering school. These companies by involving students in some projects of theirs to develop, they allow to the university to detect more specifically the needs in human resources and train the future engineers to get in the professional environment easily. These internships prepare students not only by coaching them in technical skills but also on the soft one like interpersonal and communication ones.

**Fig. 1. Modules by Category**



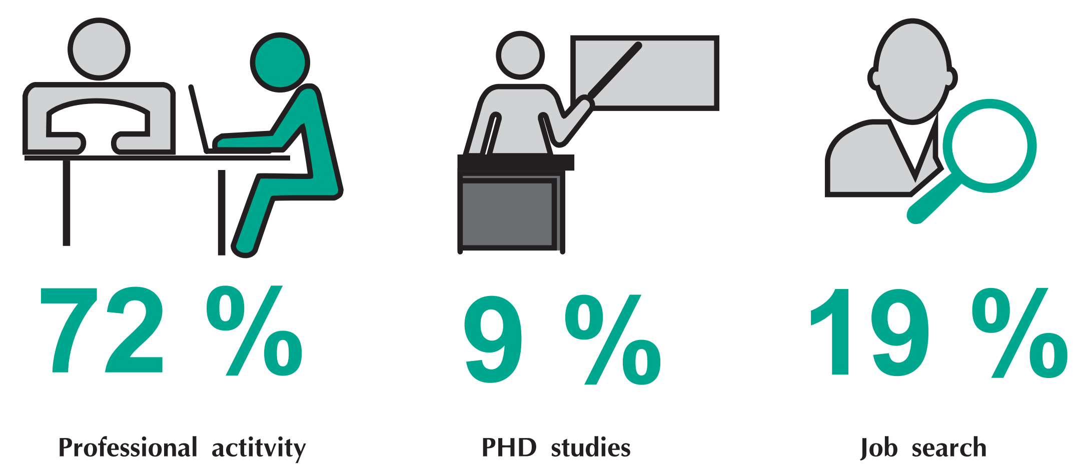



**4. International openness.** Esprit has many partnerships with universities all over the world. There are different forms of collaborating to insure the international openness to face the economic crisis of the country. Research is one of the most important keys to empower the teachers' staff ability in following the technological progress worldwide.

Esprit-Tech is the Research, Development & Innovation (RDI) entity of the university that is constituted by many teachers in many research fields who supervise students either in enterprises or in other universities partners. The objective behind this procedure is to develop their academic projects till their graduation.
The curriculum is well designed with such an elasticity that allows future generations of engineers to be multipurpose, multitask and aware of the incredible fast rhythm of progress in the technology domain.

**5. Conclusions.** In front of all these details hidden behind the pedagogical and academic aspects of Engineering Education, it is primordial to build some roots of the university with the enterprises locally and also at the international scale. That's why we cannot stop at innovating and designing curriculum without reforming the assessment methods measuring the learning outcomes. We've mentioned previously the PBL method and even the project validation but in Esprit, it is not only a question of obtaining marks but also to push engineers to participate to national and international challenges to value their efforts and competences. This challenge spirit begins with the validation of the academic realizations in an ambiance similar to the real one outside the school.

**Fig. 2. Graduates' status**



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# Shaping the Professional Competences of Undergraduates in Engineering Universities, Illustrated By the Investigation of Gas -Turbine Surface and Blade Via Its Axonometric Drafting

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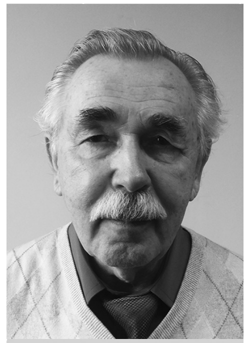

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**The article describes a course example "Research-Graphic Practicum" oriented at reinforcing previous knowledge and skills in "Engineering Graphics" and further development of professional competences of undergraduates based on the illustrated investigation of the gas-turbine blade. The authors formulated assignments in designing a theoretical model and executed an axonometric draft of the gas-turbine vane.**

**Key words:** engineering education, engineering graphics, gas-turbine blade, competences.

## Introduction

One of the major requirements imposed on an engineering university graduate is professional competences. Professional competences embrace advanced knowledge level and cumulative achievement of both general professional and specialty courses. This means that in the beginning of prevocational education, a student should be able to execute theoretical models, projecting physical phenomena and understand how to apply them.

The shaping of such a competency is illustrated by the investigation of gas-turbine unit surface and blade including further axonometric drafting of the blade itself. This article describes the practical modeling of a gas turbine blade based on the gained knowledge through descriptive geometry and axonometric projection modeling rules. Surface 3-D model type based on three plotted blade plane sections was analyzed and the axonometric projection of this space blade was described. This research was conducted by undergraduates of the Power Engineering Faculty, Moscow State Technical University n.a. N. E. Bauman.

## Ruled surface

Hands-on experience with ruled surfaces involves specific details of a gas turbine unit – a blade.

In this case, a ruled surface is precisely determined by 3-directional lines. Arbitrarily, there are only two directional lines. The position and configuration of the third directional line is selected so it would be within the "body" configuration itself, which, in its turn, is determined by the data of two other directional lines, i.e. two directional ruled surfaces determine the third plane.

Based on the spatial directional line configuration and position dependence a surface is derived. In this case, five types have been defined:

1. Standard surface configuration (oblique cylinder with 3 directional lines) is formed in straight-line motion involving three curvilinear directional lines (Fig. 1).
2. Double-oblique cylindroid surface is formed in straight-line motion along two directional curves, while the third is a straight line (Fig. 2).

**Fig. 1. Standard surface configuration**

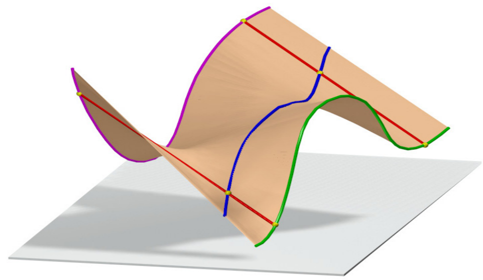
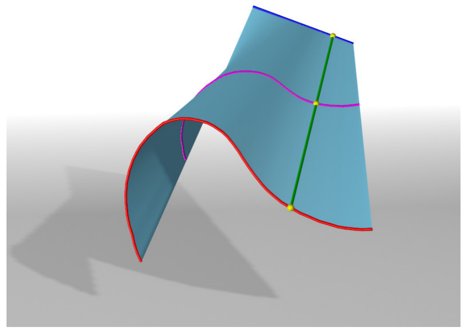
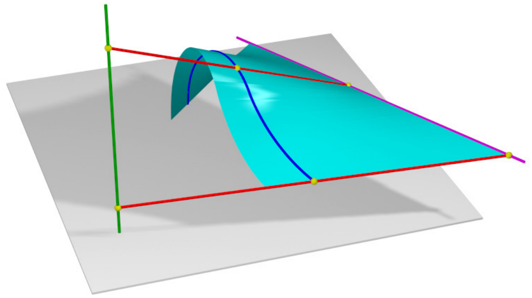


**Fig. 2. Double-oblique cylindroid surface**



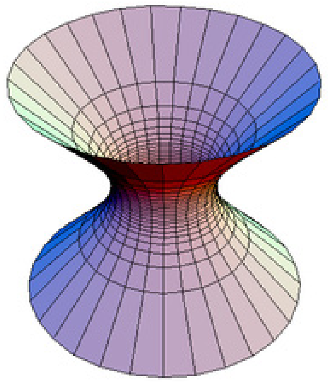
3. Double oblique conoid surface is formed in straight-line motion along the straight and curved directional lines (Fig. 3).

**Fig. 3. Double-oblique conoid surface**



4. Hyperboloid surface is formed in straight-line motion along three directional lines (Fig. 4).

**Fig. 4. Hyperboloid surface**

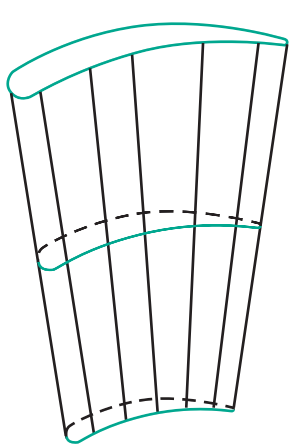


5. Ruled surface is determined by an engineering method: forming a surface intersecting corresponding points [1, p. 89-90].

Gas-turbine blade surface involves a combination of the above-described surfaces. Fig. 5 depicts a blade with limited profile surface.

Design technique of the blade channel, which is employed in engineering project course-works, provides a basis for the vane geometry itself. However, in this case,

**Fig. 5. Blade with limited profile surface**






special focus is on the graphical aspects of this engineering method excluding detailed cause-effect analysis which could influence geometric parameter alternatives.

The major values determining the parameters of blade chord and its plane section are described in Table 1, where: b – chord rotation, mm; $r_1$ – entrance radius, mm; $r_2$ – exit radius, mm; S – chord width, mm; $\beta_1$, $\beta_2$ – angles of inlet and outlet flow, degrees; $\gamma_1$, $\gamma_2$, $\gamma_3$, $\gamma_4$ – right and tangent angles to back and pressure surface in blade entry and exit, degrees; Z – blade profile section level, mm. As an example, three actual profile versions of Z sections are illustrated: root Z = 0; midsection Z = 35 mm; peripheral Z = 70 mm.

The task procedure of 2-dimensional contour in Z – sections is illustrated in Fig. 6 and 7:

Operation 1 (Fig. 6) includes plotting graphic parameters to determine the entry and exit of blade edge centers and contact points of directional pressure surface and blade back with corresponding spherical radii;

Operation 2 (Fig. 7) includes determining tangent intersection points on the blade back and pressure side (M, N). Then grids are plotted for two square parabola, dividing the distance from points M (N) to entry and from points M (N) to exit into equal numbers of segments and further connecting conjugate points.

Profile designing should be based on a significant blockage of channel towards the exit, resulting in concentration of high velocity zones along the close-range channel itself. To check blockage of the channel, a section of the second profile is plotted at t-spacing (distance between conjugate points in given section, i.e. t = 0,8 b). Further, a circle is inscribed into the channel, centers of which are positioned on the channel median (Fig. 8).

Then the median is rectified and the line enveloping the circle is analyzed (Fig.9).

**Fig. 6.**

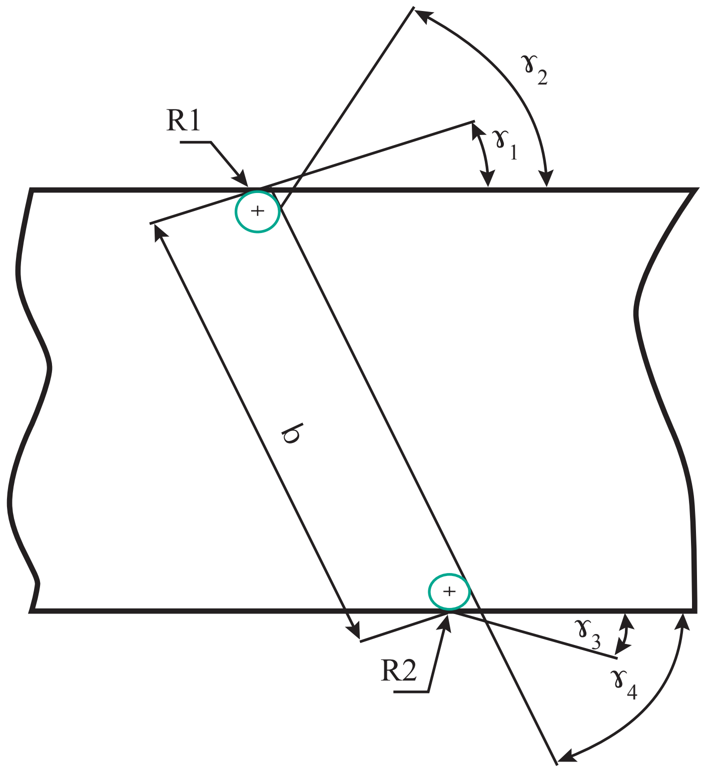


**Table 1. Initial research data**

| Version | b | $r_1$ | $r_2$ | S | $\beta_1$ | $\beta_2$ | $\gamma_1$ | $\gamma_2$ | $\gamma_3$ | $\gamma_4$ | Z |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I | 26 | 0.37 | 0.23 | 25 | 35 | 27 | 22 | 57 | 22 | 35 | 0 |
| | 26 | 0.46 | 0.23 | 22 | 49 | 18 | 41 | 67 | 12 | 21 | 35 |
| | 26 | 0.53 | 0.23 | 19 | 71 | 23 | 66 | 76 | 22 | 25 | 70 |
| II | 25 | 0.76 | 0.25 | 24.6 | 31 | 40 | 28 | 43 | 32 | 45 | 0 |
| | 23 | 0.75 | 0.25 | 20.7 | 36 | 29 | 27 | 58 | 26 | 31 | 35 |
| | 26 | 0.55 | 0.25 | 21.6 | 46 | 21 | 41 | 59 | 21 | 21 | 70 |
| III | 33 | 0.51 | 0.41 | 31.8 | 47 | 42 | 34 | 57 | 34 | 45 | 0 |
| | 23 | 0.60 | 0.35 | 21.8 | 55 | 29 | 50 | 73 | 27 | 33 | 35 |
| | 34 | 0.37 | 0.27 | 19.9 | 90 | 27 | 100 | 96 | 25 | 29 | 70 |

**Fig. 7.**

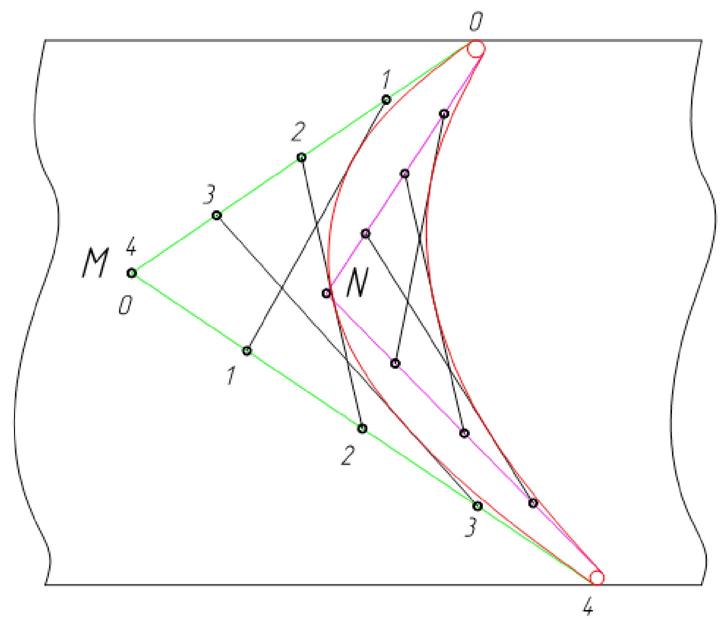







**Fig. 8.**

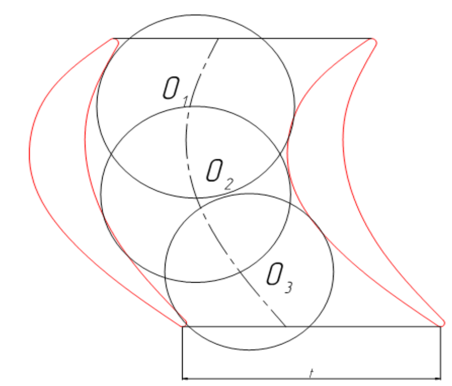
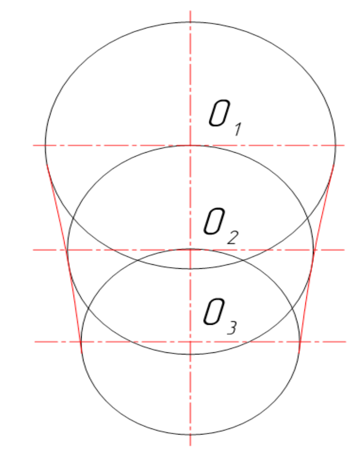



**Fig. 9.**




The smooth enveloping, contracting towards the exit, provides evidence of accurately selected sections.

Similarly, the surfaces on different channel sections were analyzed based on corresponding three plane sections (root, midsection, and peripheral – ref. Fig. 5). The center was determined in each of these sections. As a result of coinciding centroid section and considered angles the unit profile is a top view of operating blade nozzle (Fig.10) [2, p. 159 ].

**Axonometric projection of a channel**

It is a well-known fact that there are three basic requirements to an image: invisibility, visualization, and executive simplicity.

If it is difficult to imagine the object configuration in a complex drawing, then an axonometric drawing could be more visual, although it is rather time-consuming in execution.

Axonometric (from Greek "axon" – axis and "metric") projection-parallel projection in which an object appears to be rotated showing its all three dimensions. Axonometric projection shows how the principle axes are oriented relative to the projected surface [4, p. 169].

How to create an axonometric drawing? Let there be a point P (Fig. 11a), in space belonging to dimensional trihedral X, Y, Z with unit segments i, j, k. Plane XOY – P projection. Bond – P is coordinate axes of broken OPx P′ P called metric (broken) coordinate. P is called initial P projection.

Take plane $\Pi^A$ so that it cuts all the coordinate axes and choose perpendicular S projection. On plane $\Pi^A$ towards S projected coordinate axes XYZ; single scale segments i, j, k; P (initial projection and broken coordinate). Then:

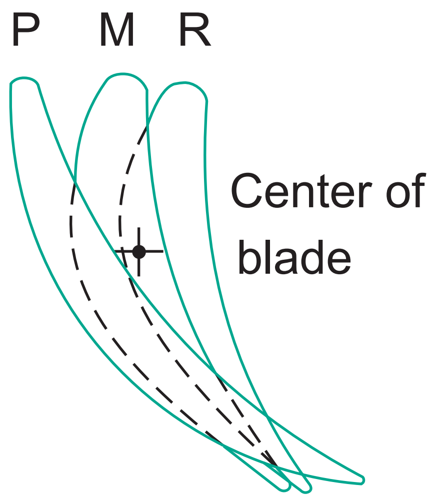
$\Pi^A$ plane – axonometric projection plane;

axonometric projection of coordinate axes- axonometric axes $X^A Y^A Z^A$;

single P axonometric projection – $P^A$;

axonometric projection of initial

**Fig. 10.**



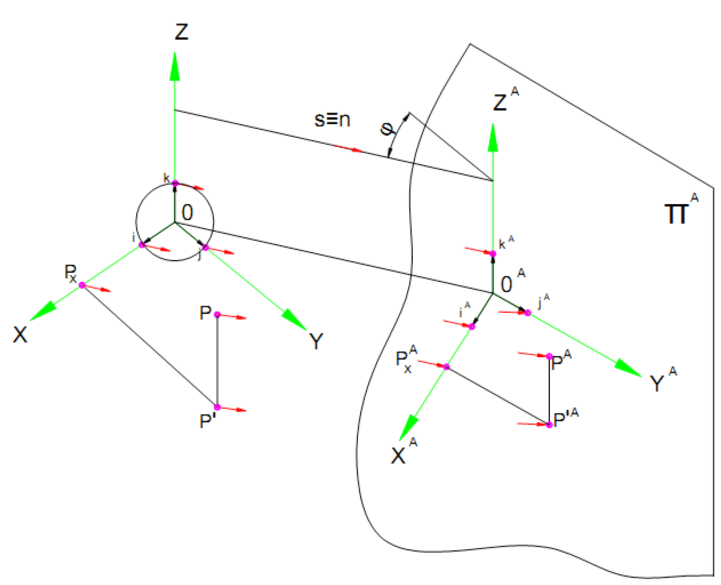

P′projection – $P'^A$;

axonometric projection of broken coordinates P - $O^A P^A$ x $P'^A P^A$.

All above-mentioned operations are positioned on plane $\pi^A$ and create the axonometric drawing.

Relation of single scale axonometric segments to actual values is distortion factor and is expressed as:

**Fig. 11a.**




$u = i^A / i, \quad v = j^A / j, \quad w = k^A / k.$

Distortion factor depends on projection direction. If angle φ is the angle between projection direction and axonometric projection plane, then we have the following dependency (Fig. 11b): $u^2 + v^2 + w^2 = 2 + ctg^2\ \varphi$.

Central projections are similar to parallel projections in that they also associate points in one set with points in another set by projection lines that pass through the associated points with the difference that the projection lines all pass through a given point. Parallel projection corresponds to a perspective projection with an infinite focal length (the distance from the image plane to the projection point).

Parallel axonometric projections are classified according to the projection direction: oblique projection – at an oblique angle, while orthographic – at a perpendicular angle ($\varphi = \pi/2$).

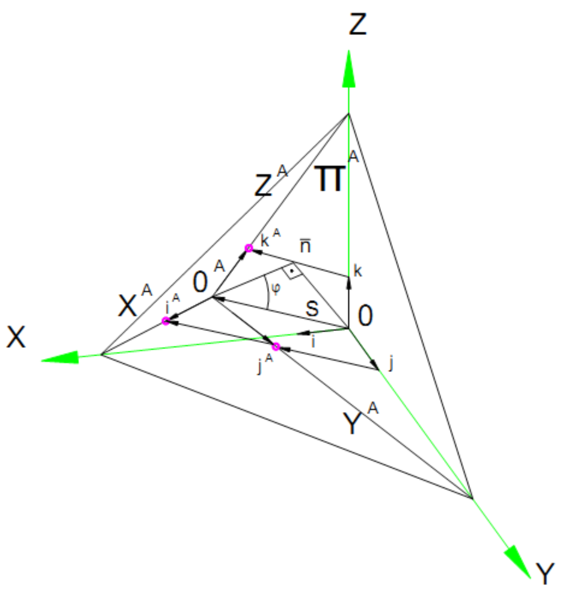
If each of the three axes and the lines parallel to them, respectively, have different ratios of foreshortening when projected to the plane of projection, this is trimetric projection. If two axes making equal angles (for example, u=v) with the plane of projection are foreshortened equally, while the third axis is foreshortened in a different ratio», this is dimetric projection. If three axes are foreshortened equally, this is isometric projection.







**Fig. 11b.**




Orthographic axonometric projection angle $\varphi = \pi/2$ and ctg $\varphi = 0$, thus: $u^2 + v^2 + w^2 = 2$. It is obvious that in the orthographic axonometric projection neither of distortion factors can be more than 1.

In engineering only two orthographic axonometric projections are used: orthographic isometric projection and orthographic dimetric projection.

Blade channel is enclosed by the back surfaces of one blade, and the other – pressure surface; channel bottom is confined to root section, while top – peripheral section. The fixed point is the entry one on the channel axis under intake conditions. Channel root plane is plotted, then, initial point of midsection is plotted along the axis Z and 2 – dimensional channel in this section is plotted.

The same operation is executed for the peripheral section. Fig. 12 illustrates an example of an axonometric drawing of a channel.

In this case, such a configuration is the blade channel. It is enclosed to the back surface (convex profile section) and pressure section (inverted profile section). The channel bottom is enclosed by the root section, in middle-by the midsection and in top-by the peripheral section [5, p. 81].

In plotting spatial blade channel image the fixed point is a point on the channel axis under intake conditions; intersection point of axonometric axis $O^A$ (Fig. 12).

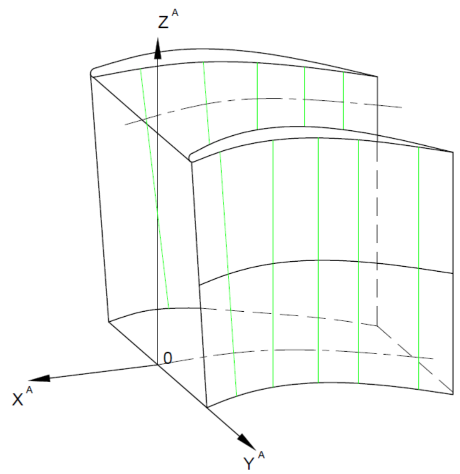
Mid profile line and spatial blade channel image is plotted for each section. Fig. 10 illustrates the mid-line in root section plane, while in Fig. 12 – one and the same line – in space.

Plotting spatial channel simplifies the problem itself, as two-dimensional lattice is being considered, i.e. a blade is on the plane. However, this does not deteriorate the relevance of this research, as the acquired skills are universal.

### Conclusions

The discussed research enhances the development of undergraduate professional competences, furthers the cross-disciplinary communication in relation to modern education standards. The students are involved in research from the very first days which reveals their creativity potential. This also initiates the understanding of complex and multi-functional problems which future student-professionals will encounter in their life.

**Fig. 12.**





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# Methodology of Engineering and Technical Activity Analisys for Development of Academic Content Standards

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**The author addresses the issue of methodology used within the institution to modify the learning outcomes of technical education. The paper represents the methodology for manufacturing process analysis conducted to develop academic content standards for engineering education of automotive profile. The content of structural elements in the analysis of manufacturing process has been substantiated. The methodology for representing production activity parameters in the form of education standards (competences) has been suggested.**

**Key words:** professional education standard, graduate's competence, education standards (competences), methodology, vocational training.

### Introduction

The methodology of engineering and technical activities analysis is an important issue today, as the universities need to determine the competences necessary for the graduates to correspond with the requirements of the regional industries.

In Institute of Transport, State University – Education-Science-Production Complex (SU ESPC), the strategic planning of educational process is aimed at supplying the demand of the automotive industry in professionally qualified human resources. Especially important is the main objective, namely, to develop professional competences relevant to the engineering and technical staff since the university graduates usually take these positions within the first two years of their professional activities.

Both technical and technological progress in automobile service and the emergence of new enterprises (authorized distributors of well-known automotive manufacturing plants) in Orel region have caused significant changes in the regional automotive industry. As a result, the automotive industry personnel and SU ESPC academic society understand the need for changes in higher professional education system and are ready for them.

Having analyzed the employers' satisfaction with the quality of higher professional education provided at Institute of Transport, SU ESPC, it is possible to state that some professional competences of graduates, who studied at the department of "Operation of Vehicles and Production Machines and Complexes", fail to correspond with the current requirements of the automotive industry. The disagreement between the industrial needs and the professional competences is caused by the fact that the traditional system of higher professional education is characterized by the lack of the dynamic response to the current technical and technological changes occurring in the industry. In Institute of Transport, this disagreement is supposed to be overcome by setting standards for learning outcomes. These standards are based on the systemic study of engineering and technical production activities. Thus, the development of master and bachelor degree programs at the department of "Operation of Vehicles and Production Machines and Complexes" is based on the analysis of the activities performed by the successfully developing automotive companies of Orel region. The professional competences determined as learning outcomes by the university standards are regarded as the information carriers of the industry requirements to the professional qualities of engineering and technical staff.

The systemic analysis of technical production activities as the basis for education standardization results from the needs of both industrial and educational spheres. It is important that the methodological knowledge within this system is regarded as practice-oriented and feasible, and providing the basis for efficient pedagogic activities.

### Methodology for the production activities analysis

Learning outcomes of the higher education institution graduates are determined by a set of competences (education standards), which a student should master within the period of studying at university [1, 5, 8, etc.]. The education standards which imply the professional competence of the graduates are determined by the requirements of the engineering industry. Therefore, the analysis of production activities provides the basis to identify the standard outcome of the professional education.

There are two model types, which are regarded efficient in terms of standardization and thus necessary to be developed. They are the model of specialist's activities and the model of graduate's learning outcomes. It is noteworthy that the foundation of graduate's learning outcomes model rests on the model of specialist's activities. It is important to identify and develop both models as they are characterized by two different objectives. The objective of the specialist's activities model is to represent fully and consistently all activity types, as well as the whole range of industrial production goals and problems solved by the personnel in charge. However, the specialist's activities model fail to be implemented into the competency-oriented educational process as it does not suggest any education standards amplified for pedagogics, i.e. graduate's competences. In its turn, the model of graduate's learning outcomes brings the data contained in the model of the specialist's activities into education standards, with all necessary educational and personality development characteristics being specified.

Automotive manufacturing operations performed by engineering and technical staff are varied and complicated. As a result, the attempt to identify operation components seems to be a great challenge. However, practice-oriented approach to this task allows finding the efficient solution: the aim of the manufacturing operations analysis is to identify the bulk of competences necessary for the graduate to cope successfully with future work responsibilities.

The manufacturing operation analysis is the source of information essential to develop education standards, i.e. competences, for a certain specialty. The necessary amount of information and its reliability are provided by the scheme of the manufacturing operation analysis.

In technical industrial engineering, one can identify three major aspects of professional activities: professional, moral and ethical, and social [9, 11]. Education standards oriented at learning outcomes comprise all three aspects and represent them as graduate's competences. In the course of the manufacturing operation analysis, each aspect is considered separately. However, only three aspects in combination ensure the efficient manufacturing operations. Therefore, considering the aspects separately is just a method to develop a complete academic content standard.

### The elements in the analysis of social and professional environment

Manufacturing operations in technical sector are performed in a certain social and professional environment. Therefore, some particularities of manufacturing operations may be identified through the analysis of social and professional environment of the companies. The social and professional environment within the sector of technical industrial engineering can be considered at two levels: macro-social and micro-social [2, 4]. Macro-social level of professional activities comprises the factors which are characteristic for the regional manufacturing. These factors are geographic, ecological, demographic, and sociocultural ones. Higher education institution graduates are employed at the enterprises of one business profile (in compliance with the graduates' specialty) but these enterprises may be of varied types. For instance, the graduates of Operation of Vehicles and Production Machines and Complexes department, Institute of Transport, SU ESPC, are employed at the automotive companies of Orel region. However, the companies differ. According to the data on the demand for human resources at the geographical market, the graduates may be employed not only at service stations, but also at logistics companies, automotive companies which sell cars and repair parts, and filling stations.

In the manufacturing process analysis, it is important to study the elements, which reflect the micro-social level of the social and professional environment. In contrast to the macro-social level, which is under the influence of the regional particularities, the micro-social level implies the company's characteristics. The analysis at the micro-social level includes the following elements: technical, technological, organizational, and socio-psychological [7]. These aspects being taken into account, the manufacturing operations analysis represents the complete range of particularities characteristic for automotive companies. It is important to note that different automotive companies are characterized by different elements of the micro-social level. For example, technical and technological aspects are the most relevant for service stations. For automotive companies selling cars and repair parts, economic and socio-psychological aspects are the most significant since one of the most important employee's abilities is to influence the buyer's choice. It is possible to conclude that the starting point for development of the professional activities model is identifying sociocultural elements characteristic for these activities. One should take into account that the objectivity of information obtained at this stage results in adequacy of competences (education standards) developed on the basis of these data. Taking into account all analysis aspects, the professional activities might be represented as a core model. The core is an operational component of the professional activities while the surrounding layers are macro-social and micro-social levels. Each element specified is a complex object with a particular structure. Thus, the core structure includes the components as follows: types of manufacturing operations, employee's responsibilities, types of manufacturing tasks to be solved by the employee. Considering the whole structure, it is possible to identify the elements of particular professional and social environment, which will be used as a basis to develop academic content standards.

If to consider the components of different elements within the model of professional activities, one can identify significant correlations. Developing the macro-social element of the model, it is possible to recognize the particularities of professional activities, which are characteristic for the region. These data make the core of the model, i.e. the types of professional activities. These types allow determining the functions fulfilled by the employee. As a result, it is possible to represent the model of professional activities in detail.

Many technical and technological changes regularly occur in the automotive industry which is intensively developing. What is important, the structure of the manufacturing operation model can be modified in response to these changes. It is noteworthy that the structure

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allows considering the impact, which a modification has on the other elements. This makes it possible to modify, specify, and update the academic content standards.

### Manufacturing process environment: the stages of analysis

To develop education standards, one should identify the bulk of competences necessary for the graduates. The analysis of manufacturing process environment includes several consecutive stages. To get the data relevant to the analysis objectives, it is important to determine the order of stages for the procedure to be consistent. This can be provided if the stages of the analysis correspond to each other: the statement formulated at a certain stage should appear in evidence of the conclusion made at the previous stage and condition the statement of the following stage.

The first stage is understanding of and argumentation for necessity of correspondence between the graduate's professional competences and the efficiency of activities performed by the company staff of the same qualification. The second stage is setting the aim of the manufacturing operation analysis. If the aim of the manufacturing operation analysis is to design the graduate's competence model, the development of education standards (i.e. competence content) is the objective of the second order [8]. It is important to note that in virtual university environment the manufacturing process analysis can be initiated by the administration order to develop the graduate's competence model for a certain specialty; however, this does not exclude the first stage when the importance of this task is realized. Under these circumstances the first stage seems to be vague but it still exists. To get the efficient results, all analysis stages should be passed through: it can be done in the direct order (towards the analysis aim) or in the reverse order (restoring the whole context of the analysis). Therefore, under the circumstances described above, the first stage should be restored even if the analysis started with the second stage.

The aim of the manufacturing operation analysis, i.e. identification of the graduate's competences corresponding to the demand of the regional human resources market, is determined by the industry, on the one hand, and the higher education institution, on the other hand. These two options are not exclusive but mutually supportive. The goals of the two social spheres are different: while the industry needs efficient human resources, the institution aims at improving educational process. The global aim, namely, identification of competences, is achieved only through collaboration between the institution and the companies-partners.

The third stage of the analysis is to set the pedagogical problem, which is to be solved through the analysis. The pedagogical issue of education standards should be appropriately considered. Thus, the aim of the manufacturing operation analysis, i.e. identification of the graduate's competences, identifies the pedagogical problem connected with the forms of competences' representation. Moreover, the form of representation should be appropriate as an instrument of feedback connection between the institution and the enterprise. Therefore, it is necessary for the education standards to contain complete and consistent information on the industrial requirements for the professional education. It is a well-known fact that the adequate representation of manufacturing process requires its formalization [12]. Formalization implies that the phenomenon being analyzed is split into structural elements. In the course of the manufacturing operation analysis, the responsibilities of the employee are formalized and represented as the graduate's competences. Consequently, the formalized description of professional responsibilities provides us with all particularities and details which should be taken into account. Another supportive argument for this procedure is competences themselves being relatively constant and well-defined.

The fifth analysis stage is the choice of the object. Manufacturing process as the analysis object is a complex integrating work objects, tools and instruments, technologies, production relations. The complexity of the analysis object ensures the analysis sustainability. As the object is complex, analysis methods should be complex as well to obtain the data necessary for the development of academic content standards. The analysis is conducted at different levels and provides complete understanding of the object. Moreover, the analysis complexity in ensured through considering the object from interdisciplinary perspective, which integrates the following disciplines: the economics of business enterprise, technical tools and their application, enterprise management, psychological and social aspects of work, etc. Multi-level analysis implies considering each element of the manufacturing process in terms of its content and function, which the element performs within professional and social environment. This helps to identify personal qualities of an employee as a specialist and as a member of social fabric.

Thus, multi-level analysis makes it possible to regard the object, namely, professional activities of technical profile, from different perspectives, which provides the data sufficient to develop academic content standards. Multi-level analysis allows identifying particular states of the object, which reflect various aspects of the unity [9]. The particular levels provide the researcher with complete and consistent information on the requirements for the specialist qualification which ensures professional success. Moreover, multi-level analysis makes it possible to group education standards reflecting the graduate's learning outcomes. It seems reasonable for the number of education standards (competences) groups to be equal to the number of aspects considered. It makes the standards well-structured and consistent as well as prevents amorphousness in the description of the standard components.

Engineering and technical activities make up a complex object [12]. As a result, the levels are distinguished conventionally. Therefore, there are no strict criteria which allow referring the particular element of production activity to the particular level of analysis. The principle of completeness in the description of the object implies identifying the complex of parameters which characterize the professional activity. To fulfil the pedagogical function, namely, to develop the professional education standard, it is enough to provide the complete description of the corresponding competences. It is noteworthy that completeness of description can never be absolute but only sufficient for representation of feasible activities performed by the specialist. More important, the aspiration to complete representation of all parameters of the object may cause the lack of emphasis on the major aim of the analysis, i.e. academic content standard. It is the empirical process of analysis that can ensure the optimal completeness in the description of the object parameters and consequently the optimality of academic content standards.

The empirical analysis is an essential condition to develop hand-on education standards (competences) of technical profile. The complexity of manufacturing process requires the empirical research of its parameters. However, the empirical character of the analysis does not eliminate the importance of the theoretical basis. The empirical approach to manufacturing process analysis is chosen to prevent an opposite approach – a priori one. A priori choice of manufacturing process characteristics inevitably results in the lack of accuracy, which weakens the relevance of education standards to the feasible professional qualities demanded by the industry. As a result, empirical approach to manufacturing process analysis verifies academic content standards in terms of their completeness and reliability. Most important, the empirical analysis ensures operability of education standards and consequently the efficiency of educational process at higher educational institution.

**Methodology of representing production activities in terms of education standards**

The important stage of education standardization is transformation of production activity parameters into education competences. The parameters of production activity represented as education competences are to reflect the manufacturing process without any distortion. On the one hand, any parameter of production activity represented as a competence should be recognizable for the employee of the relevant industry. Therefore, the use of any pedagogical or psychological terms in the description of the competence content is unappropriate, even if the terms express the idea of the competence to full extend. Under these circumstances, the competence content should be described in the terms typical for the social and professional environment of a given industry [7]. On the other hand, each competence represents the education standard and its content should not be reduced in purpose to simplify wording. Each professional competence as a learning outcome reflects a particular parameter of the production activity. It is obvious that each education standard should be self-contained. Therefore, the competences should be independent of each other: the competence should never contain any elements of the other competence, in other words, they should not be overlapping. However, it is important to ensure interconnection and complementarity of competences [8]. This thesis is supported by the principle of completeness in education stastandardization, which indicates that the competences, each representing the total learning outcome, should be interconnected as the parts of the whole. The unity of competences within one structural group are unilevel and homogenious characteristics of a particular professional education parameter [8]. It is obvious that the list of competences reflecting production activity parameters should be tested for the completeness of representation. It is stated that the list of graduate's competences may be modified and updated. However, the competences added to the list are not to double the content of other competences. For the experts who estimate the list completeness, it is important to consider that the list of competences represent only the most significant parameters of future production activity. This is the reason why the completeness of the list is supposed to be sufficient but not absolute. It seems to be reasonable to add the competences which were supported by no less than 75% of experts (on the basis of the probability rate of consistent coincidences). This will ensure that the connection between the lists of competences regarded as essential by the experts is significant and positive. The competences beyond the list are considered by the experts as minor. The number of competences at any level can never be limited or set in advance. Every time when the academic content standard is developed for a particular specialty, the number of competences is set by experiment since each profile of production activity is characterized by specific features.

**Conclusion** The author's experience in the development and implementation of principle bachelor and master degree programs for "Operation of Vehicles and Production Machines and Complexes" at SU ESPC (Orel) proves the efficiency of the methodology suggested for development of academic content standards of technical profile. The major advantage of the methodology is orientation at learning outcomes of professional education one the basis of the industrial demand for professional competences of engineering and technical staff.







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# Creativity Components in Engineering Education

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**The article describes the conflicts in the development of engineering education, their algorithm definitions which would be eligible for engineers, researchers, instructors, and students. This, in its turn, is the result of long-term experience in the development and application of about 20 algorithms based on TIPS (Theory of Inventive Problem Solving).**

**Key words:** engineering education, creativity algorithms, system, function, Theory of Inventive Problem Solving (TIPS / TRIZ), contradictions.

## Introduction

It is a well-known fact that engineering education, comparable to Humanitarian and Natural Sciences, has its own specific features. Hand-on experience involves applying the theory of inventive problem solving (TIPS / TRIZ) in teaching some engineering disciplines in Chuvash State University n.a. I.N. Ulyanov (CSU). In the publications [1, 2] the experience in implementing practice-oriented educational technology into the engineering education was described. The existing tendencies prevailing in the transformation process of the engineering education itself (including the content and technology strategy) "block the hope" in furthering changes in the engineer training today. In [2] the experience of the Siberian Federal University (SFU) in shaping engineering competencies relevant to today's knowledge structure, skills and abilities, as well as developing those competencies to generate modern ideas has been described. Taking into account the modern approaches – Theory of Inventive Problem Solving (TIPS / TRIZ) [2-5] and the experience of SFU the up-dated learning strategies and IT have been proposed. People with creative thinking, competent to generate and develop ideas are imperative of our days when the country is entering the path of innovation development. The generation of up-dated innovative ideas is becoming more and more relevant as an aspect of human activities due to the gradual change to a well-established innovative civilization and the rapid emergence of the fifth and/or sixth technology revolution [1]. These factors highlight the role of a talented-thinking person in this process.

A knowledge database [6-10] for professionals, engineers, instructors, and students has been developed in CSU. This database involves 30 books in TIPS (TRIZ) (600 copies) and 15 manuals published in CSU (more than 100 copies) in 1976-2014. These manuals embrace different intellectually-demanding learning tasks in chemistry, environment protection, metalworking, electrical engineering, business, and IT. There are consulting programs, i.e. computer programs and videos in TIPS (TRIZ) in the CSU computer classes (Computer Information Center). The students become acquainted with the fundamental principles of TIPS (TRIZ) which include [3-13]: system approach, generalized experience of many inventors via problem-solving algorithms, as well as demonstration examples of creative patent-decision making actions in different domains of technology and science. The students study in TIPS (TRIZ) School, as well as at some advanced courses developed in the Computer Technology and Radio Engineering departments.







Engineers should be involved in inventive problem solving based on Inventive Problem-Solving Algorithm (IPSA) projects developed in 1961-1985 (in the USSR) and being further developed today. Advanced methods and simplified approaches for beginners are being developed. It is a well-known fact that students are becoming acquainted with TIPS (TRIZ) components in more than 800 Russian engineering universities. However, TIPS (TRIZ) proficiency is practically impossible as TIPS (TRIZ) is not considered to be an essential engineering discipline, and consequently, few academic hours are included in the university curriculum.

The basic principles and methods of TIPS (TRIZ) are discussed:

**1. System approach.** TIPS (TRIZ) includes the examination of system organization and structure, their functions (principal, subordinate, supplementary, negative), recording of system errors (more of something desirable, also brings more of something less desirable, or less of something else also desirable ). Recording predominant laws of technical systems evolution: a) ideal system (IS) or towards ideal final results (IFR); b) system improvement via IFR results in emerging technical (TC) and/ or physical (PC) contradictions which should be resolved. Conscious recording of these laws of technical systems evolution reduces lost searching time for new creative decisions, diminishes the number of decision errors (1000 to 3-7 close to implementation) and improve the quality of ready decisions.

**2. Professional evaluation of creativity.** According to the professional evaluation of creative technology, in cases of random search method (i.e. excluding knowledge of system evolution laws in problem-solving according to the so-called "trial-and-error method" – T&EM) only one of 3000 commercially proposed ideas are accepted; while in cases of direct search method (based on the system evolution laws) 3-7 practical ideas are found [2-13], then, after engineering-economic quantitative assessment, only 2-3 ideas are selected.

**3. Description of TIPS (TRIZ) methods.** Description of the tools and methods based on TIPS (TRIZ) of various complexities for both learners and professionals are depicted in Table 1. The methods differ not only in the number of included TRIZ steps, but also the applicability for different types of inventive problem solving (involving one person and/or a group of professionals; or several groups of different-employed professionals). The method types in №№ 1-5 are simple and practical for examination and application in the start-up introduction of TRIZ principles and further proficiency: they are operated by a single solver. Method types №№ 2, 10-12, 14 are based on intelligent computer-supported programs: Expert Systems-Invention Machine- IM 1.5 (Research Lab of Expert Systems, Minsk, 1989) and / or foreign analogues: TechnoOptimizer-TOP 2.5 ( IMCorp, Boston, 1997), GoldFire-GF 3.5 ( IMCorp, Boston, 2007) and Invention Machine-IM 2.4 (St. Petersburg, 2004). The users also developed numerous simple search-based computer programs, for example, № 1 (according to G. Altshuller 40 Principles). Method types №№ 6-9, 12-15 are considered to be complex and more complicated.

**4. TRIZ and Instructions.** What has been accomplished in TRIZ instructions for students and professionals? A. Gin reported about the 15-year experience results of the Laboratory of Educational Technology [12,14] at TRIZ-conferences. More than 30 manuals have been published in different disciplines which include the introduction and training of modern approaches to open problems (numerous possible correct solutions). These manuals and books have been published in many languages. Students should understand that they would have to encounter different open problems and it is the TRIZ methods which could help solving them. New numerous manuals to assimilate TRIZ

**Table 1. Methods of inventive problem solving based on TRIZ [15]**

| № | Methods types | Number of steps | Problem type | References |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 1 | ARIZ and 40 principles: Atlshuller table (1972) | 5+ | simple | [3, 8, 13] |
| 2 | Brainstorming technique (software based) – S. Malkin "Guided Brainstorming LLC" (2012) | 6+ | simple | [14] |
| 3 | A. Podkatilin 5-20 steps (2008) TRIZ-1 – theory of inventive problem solving (level 1) | 5-10 | simple | [13, 15] |
| 4 | Algorithm SIE (ARIZ-77 – part 1 and Atlshuller table, CSU) | 15-20 | simple | [10, 13] |
| 5 | ARIZ-76 Atlshuller table (1985) | 1-10 | simple | [3, 4, 13] |
| 6 | Algorithms for inventive problem solving ARIZ-85v (1985) | >100 | complex | [3, 4, 13] |
| 7 | Algorithms for selecting engineering problem solving – ARIP (G.I. Ivanova, 2010) | >32 | simple-complex | [15] |
| 8 | TRIZ-3 – A. Podkatilin, advanced level including application steps (2015) | >>10 | complex | [20] |
| 9 | Algorithm G3-ID (GEN3-Partner Inc., US) and Algorithm (S. Litvin, St. Petersburg, 2000) | >>100 | more compli-cated | [15] |
| 10 | Algorithms of Idealization TRIZ, Direct Evolution (B. Zlotin, US, 2006) | >>100 | complex | [15] |
| 11 | Invention Machine Program IM- 1.5 (V. Tsrikov Research Lab. Of Expert Systems, 1989 Minsk | 5-100 | simple-complex | [10, 15] |
| 12 | TechnoOptimizer Program TOP-2.5 (IMCorp, US, 1997): TC-algorithm, ARIZ and 40 principles, contradictions (PC, AC, TC), standards and final results | 5-100 | simple-complex | [8, 13, 15] |
| 13 | GoldFire-3.5 – decison-engine platform (IMCorp, US, 2007) | 5-100 | simple-complex | [15] |
| 14 | Theory of Evolution of Matter and Models-algorithms for IT problems (M.S. Rubin et al., 2012 | 5-100 | simple-complex | [15] |
| 15 | Algoritm MO-2.4 (V.V. Mitrofanov, 2004) | >7 | science-based | [ 15] |
| 16 | ARIZ-2010 (S. Litbin, C. M. Rubin, V. Petrov et al., TRIZ- Conference Meetings 2005-2013) | >100 | simple-complex | [15] |
| 17 | Subversion analysis (B. Zlotin et al., 1989) | 5-100 | simple-complex | [15] |
| 18 | Future evolution of systems (B. Zlotin, S. Litvin) | >100 | complex | [3, 5, 15] |







in solving technical, chemical, business and ecological problems are being published [5-16] in CSU, TSU, and TSUAB.

**5. Simple algorithm to analyze the problem.** One of the simplest and most effective TRIZ methods is Brainstorming algorithm. A summary of this algorithm [14] is formulated in the following example which includes 5 steps (note: empty pair of parentheses with dots embraces specific content for this or that problem).

The main purpose is the transition from an indefinite initial problem situation to the clearly formulated and extremely simplified description (model).

Problem Model:

**Step 1. Mini-problem conditions:** (state the purpose of the system in economy, technology or human relations; list the main parts of the system introducing such requirements as: current level and future required level, what is impossible to change? how to determine the progress? minimum level? what required result (…) what contradictions? (…) (…).

**Step 2. IFR** (ideal final result): state the **required result** (…) under conditions (…), where (…) and when (…).

**Step 3. Transition to problem situation:** includes 5 questions denoting the technical parts of the system (Technical Contradictions) – a) introduction (improve-ment) b) elimination (reduction), c, d, e) identifying contradictions (changing action / substance / parameter (…) improving useful action (…), or eliminating a harmful action (…)).

**Step 4. Analyzing the problem model:** The following list (Table 2) of 30 interrelated abstract inventive resources [3, 14] is intended for identifying available potential that may be useful for solving the problem.

To identify the idea in the first group "resources" a new operation (or their combination) is applied as a hint for further identification of new ideas via the transition of an element or function, action, interaction, environment or another system. Could such an operation develop a new resource and / or change the result? It is recommended to consider the remaining operations to eliminate the contradictions and conflicts with respect to defining the resource.

When considering the operations it is necessary to remember that there

**Table 2. Abstract inventive resources**

| | AVAILABLE RESOURCES | | | | | |
|---|---|---|---|---|---|---|
| Operations | RESOURCES | TIME | SPACE | STRUCTURE | CONDITIONS & PARAMETERS | |
| | Energy | Ahead | Alternative dimension | Elimination | Partial | Inoculation |
| | Substance | After | Asymmetry | Degradation | Redundant | Isolation |
| | Information | Gap | "Russian Doll" principle | Consoli-dation | Consistent | Counter-measures |
| | Derivatives | Accelerate | Exportation | Mediator | Dynamic | One-time |
| | Concent-ration | Decelerate | Localization | Copy | Controlled | Inversion |

are 300 inventive operation application examples for different problems: technical, economic, or human relations.

**Step 5. Formulating problem model:** estimate the utility and/or harmfulness of proposed ideas as a complementary solution mode, identify new possible problems, and, if necessary, repeat the search for other ideas and develop an implementation plan.

**6. Problem example:** Hydrated dust cloud in a workshop

Problem: In a workshop (Perm R&D Instrument Engineering Co.) there is a deactivation unit for acid waste solution HF + HNO3. The process is as follows: 1) a sack of crushed caustic limestone is emptied into a tank (with water and mixer); 2) pressurized oxygen absorbs the finest CaO particles; 3) this hydrated cloud spreads throughout the workshop; 4) there is an outlet ventilation with hood above the tank. The worker is dressed in a PE and respirator. However, the workers from other workshops complain of this situation. All complaints are sent to the Health & Safety Department.

**Step 1. Stated problem:** technical and personal interrelations. What should be changed and what cannot be changed? – acid waste water should be completely neutralized. Why? – cheap caustic limestone (CaO) is suitable in this case. What conflicts? – when dispensing powdered CaO, hydrated dust cloud is formed. Stated task – to cut-off the formation of hydrated dust cloud in the workshop air.

**Step 2. IFR:** in the process of dispensing powdered caustic limestone CaO into the neutralization tank, the CaO dust cloud itself does not enter the atmosphere.

**Step 3. Substance-Field Resources (SFR) 1:** 3.1 Clear up the dusty air in the workshop. 3.2 Eliminate the dust cloud path in the workshop. 3.3 TC-1: powdered CaO is necessary to neutralize the waste solution; however, in the process of CaO dispensing, a dust cloud forms in the tank hood due to emitted pressurized oxygen from the tank itself. 3.4 TC-2: dispensing powder is necessary to neutralize the waste water; however, a bad result is the formation of a harmful dust cloud due to the aerodynamic flow in the hood itself (i.e. powder contains dust particles, and it is this dust that forms the harmful cloud in the air).

**Substance-Field Resources (SFR) 2:** all operations are necessary.

**Step 4. Analyzing the problem model** (30 operations are applied: Energy (E) = Mechanics - Acoustics - Surface Radiation - Electricity - Electro - Magnetic Waves - Chemistry - Biochemistry - Nuclear Physics; (S) = Substance; (I) = Information; Time; Space; Structure; Conditions and Parameters). Operation groups are applied (Table 2).

4.1. Resources: 4.1.1. Mechanical – dynamic (E) dispensing powder forms aerodynamic flow. 4.1.2. Substance (S = solid - liquid - gas - plasma) powder flow + gas current → capture zone. 4.1.3. Information (I): explanation that the neutralization of waste water is conducted once a week – rarely; major ecological problem – complete neutralization, but no rush. A sack – 20kg. CaO, CaO capacity – 7 liters and pressurized 7 liter of air (from the tank). 4.1.4. Derivative (from E/S/I): neutralize slowly, but accurately excluding harmful dust cloud. 4.1.5. Concentration (E/S/I): premixed concentrated caustic limestone solution, but this is an unwanted operation, as the solution cannot be stored over a long period – sediments accumulate in storage.

4.2. Time: 4.2.5. Slowed down operation – in the process of slow CaO powder delivery, the dust cloud formation is less.

4.3. Space: 4.3.2. Asymmetry – assuming, powder flow embraces only 0.1 portion of the hood area, then the sack is opened partially, scissor off sack corner and thinly pouring out; 4.3.3 "Russian Doll" – jet-flow of powder into a pipe, not contacting with air current; 4.3.5. Localization – powder in the pipe.

4.4. Structure: 4.4.1. Elimination – powder - air contact flow; 4.4.2. Degradation – pouring out partially, while 1/20 portion by a bucket; 4.4.4. Mediator – bucket + funneled pipe to provide precise dosage, as well as separate powder and pressurized air flows from the tank.

4.5. Conditions: 4.5.3. Matching – portion volume (bucket) is matched to required precise dosage; 4.5.5. Controlled – bucket is regulated manually.

4.6. Parameters: 4.6.2. Isolation – mainly isolate the flows.

**Step 5. Model:** 5.1) (based on operations 4.1.3 + 4.2.5 + 4.3.2) – thinly empty CaO from the sack (scissor off sack corner), then the dust would be less; 5.2) (add operations 4.3.3 + 4.3.5 + 4.4.1) – empty through a pipe funnel, then dust formation would be completely excluded; 5.3) (add operations 4.4.2 + 4.4.4 + 4.5.3 + 4.5.5) – empty partially the sack, where CaO dosage is performed by a bucket (at 0.5-1 kg.), then two problems will be solved; major – precise dosage (100-110%) CaO, excluding dust formation. The Customer suggests a set of 3 proposals.

**7. Practical application of TRIZ.** Three factors proved the effectiveness of professional TRIZ application within developing innovative enterprises and companies [5-8, 13-16, 20]: 1) a 20-year application of TRIZ in technical problem solving of varying complexity within hundreds of USSR enterprises (followers of G. Altshuller, S. Litvin, B. Zlotin, A. Podkatilin, G. Ivanov, and others); 2) 20-year experience of integrated TRIZ application based on the TIPS supporting-based programs (such as TechnoOptimizer and GoldFire); and 3) personal engineering experience of professionals from transnational companies and corporations of USA, Western Europe, South Korea and other countries.

To introduce, train, and further apply TRIZ in the research of students and CSU teaching staff, TRIZ training programs [4, 7, 15, 17] were proposed within the framework of Innovatik School, Computer Technology Department and CSU Education Center (Table 3). These programs include an introduction into the basic TRIZ principles and problem solving of about 30 drilling problems in technology and business management. During the classes (practicum) methodological, technical and science-based failures, inaccuracies and errors are discussed and corrected and/or improved. It should be noted that not only executives of academic and R&D organizations, but also students propose their own practical problems. To extend knowledge and enhance the understanding of the basic TRIZ principles and its components, it is recommended to develop supplementary materials, additional guidelines, and problem books.

The 40-year experience results in training TRIZ and its practical application has been described in the book "Basic Fundamentals of the Theory of Inventive Problem Solving" [13]. For example, comments of A. Pizhenkov (PhD in Chemistry) (2013): "How did your book help me? Solving 20 problems I used the database www.dace.ru, where I sometimes found the answers. I also applied ARIZ-85v, platform technology evolution, system operator, algorithm SIE (ARIZ-77), my personal knowledge in chemistry and physics. Your book [13] is simple and understandable. You can learn independently. Although there are some specific problem examples, but they are "stand-alone". Earlier, I read books in TRIZ which were "blurry" and rather difficult to understand". Based on ARIZ and 40 principles; and algorithm SIE [13 - pp. 118 and 253] the following problems were solved: technogenic load decrease on environment during petroleum development via oilfield pipe protection from pitting erosion (patent RU 2534134, published 27.11.2014); eliminate four technical contradictions (TC) typical of modern individual transportation; proposed universal pneumatic transport system (patent application RU 2011149865, published 27.06.2013). The following achievements should be mentioned: e-learning in TRIZ, 30 published manuals

**Table 3. Student Course schedule (TRIZ School)**

| № | Lecture topics | hours | Practicum topics | hours |
|---|---|---|---|---|
| 1 | TIPS – Theory of Inventive Problem Solving (in Russian TRIZ) – basic principles. Video | 2 | Presentation – TRIZ, different problems | 4 |
| 2 | Stated problem. Problem example | 2 | Example problems | 4 |
| 3 | Ideal final result (IFR). SFR-concept (technosystems) | 2 | Example problem – its presentation | 4 |
| 4 | Substance-field resources (SFR): provided and derivatives | 2 | Example problem – its presentation | 4 |
| 5 | TRIZ and three different models | 2 | Example problem – its presentation | 4 |
| 6 | ARIZ algorithm – 30 principles: 6 steps | 2 | Example problem – its presentation | 4 |
| 7 | Mini-problem conditions, transition to problem situation, and analyzing problem model | 2 | Example problem – its presentation | 4 |
| 8 | Formulating problem model and practical application | 2 | Summary – test | 4 |
| | Total: | 16 | | 32 |

for colleges of Russian-American A. Gin group, inventive stories of M. Shusterman [18] and V. Galetov [19].

**Conclusion.** The authors described 18 TRIZ methods of different complexity, which are available for innovator-users. A training program of TRIZ-method for beginners and instructors was proposed. TRIZ-method is applicable in solving practical problems. Students-engineers should be acquainted with TRIZ components in their futureinnovation activities.




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# Peculiarities in Shaping Staff Professional Skills in Fishery Industry ("Production Machines and Facilities" Education Program)

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**In leading countries, fishery industry is characterized by high scientific and innovation potential, which makes it one of the leaders at international consumer market. The Russian fishery industry is significantly lagging behind not only other countries in terms of hydrobionts' processing technology, but also Russian pharmaceutical companies and biotech firms.**
**One of the reasons why Russian fishery industry is lagging behind is low professional level of engineering staff involved in this production. To remedy the situation, it is required to revise engineering training transferring it from qualification-oriented approach to competence-based one, with a graduate acquiring not only professional competences but also skills in innovative ventures.**

**Key words:** fishery industry, engineering training, professional competence, innovative venture, process engineering, practice orientation.

Having high scientific and innovative potential, food industry takes a leading position in the countries with developed market economies [2]. The scale and pace of its development is defined not by the commitment of certain economic sectors to structural changes and investments, but by market conditions and, primarily, rate of consumption demand change.

Today, food industry is naturally combined with biotechnological, microbiological, chemical and other branches of industry as it actively uses such products as food additives, flavoring, structure-forming agent, packing, and other ingredients used in food technology [10]. The food industry involves a great number of various machines and equipment to maintain complex technological processes of transferring raw material into semi-products and end products. While being processed, raw materials undergo physical, physico-chemical, microbiological, bio-technological and other processes which change their aggregate state, internal structure, and composition. This requires professional staff to have integrated knowledge in characteristic features of the above-mentioned processes since such kind of knowledge is the fundamentals of food technology [2, 8].

The present state of food-processing industry of the Russian Federation (RF) can be characterized as pre-crisis as the export of raw materials and import of end products have been priorities of the country over the past 10 years [7]. Actually, this has contributed to the lagging behind of Russian food-processing industry and degradation of engineering staff professionalism of the corresponding companies. At the same time, it is a well-known fact that it **is engineering development that defines innovation progress of any country.**

To bridge a gap, the RF Innovative Development Strategy up to 2020 has been developed to reinforce the position of Russia at the markets of high-tech and intellectual products by increasing the share of high-tech sector in gross domestic product (GDP) from 10.9 up to 17-20%, while innovation-driven companies – from 9.4 up to 40-50% [7]. This goal is complicated by the fact that foreign products must be substituted by domestic ones within a short time period. To achieve meaningful outcomes in such a competition, the country needs for breakthrough technologies and innovations that would change the situation at high-tech product market in favor of the RF [9]. The breakthrough innovations bring new technologies, on the basis of which product lines are developed. This creates jobs at large industrial complexes or even within industrial sectors.

In this respect, it becomes obvious that qualified engineering staff having **competence in innovative venture** will be in high demand in the near future.

This is due to the fact that Russia has to surge ahead towards mass process of innovative product development. Engineering business activity is focused on generating new ideas and inventions followed by product sales in accordance with market demands. To be effective in this sphere, fundamental engineering education, sufficient for understanding technical peculiarities of the improved or new product, and business skills, necessary for consumer satisfaction, are required.

The current technological state of fish-processing industry remained at the level of the 1990s and is significantly lagging behind foreign competitors [4]. For example, depreciation of basic production facilities and processing equipment has exceeded 70%, with canning facilities being utilized up to 44.8%, industrial cooking – 42.1%, smoking facilities – 23.4%, refrigerating systems – 26%. It means that the level of production facilities use is less than 50% across the country.

Most fish-processing plants located along the coastline have not renovated production and processing facilities for a long period of time. This has resulted in low use of raw hydrobionts, poor quality of end products and absence of production wastes re-use. The insufficient level of technological advancement has become one of the reasons for reducing fish production volume, therefore, foreign products account for more than a half of the domestic hydrobiont market.

In recent years certain progress has been made in fish production and it is currently on an equal footing with other agricultural industries. Precisely, the growing rate of fish production volume is 7.5%, while the share of domestic seafood products at the consumer market increased by 4.6%. The increase in production volume of certain types of fish products is also a good sign [3]. At the turn of the century, there was a dramatic breakthrough in technological infrastructure of a number of fish-processing plants due to implementing innovative and cost-effective production machines and facilities. The technological infrastructure of these enterprises was expanded by a wide range of up-to-date machines and equipment which are involved in complex technological processes, i.e. multi-stage processing of raw materials and semi-products. This leads to significant enhancement of traditional technological processes and implementation of new hydrobionts processing technologies. Based on the level of technological advancement, these enterprises are competing with leading foreign companies or even surpassing them in certain production aspects.

However, it should be stated that the competitiveness of domestic fish-processing industry is still rather low, which is resulted from weak investment activity, insufficient level of technological infrastructure and logistics, as well as lack of qualified engineering staff. Moreover, the level of fish-processing industry development significantly lags behind not only the world's leading hydrobiont processing companies, but also domestic high-tech industries, such as biotechnology and pharmaceutics.

Most engineering solutions are proposed with no regards to machinery specifications, analysis of technological system potential under certain operation conditions and in relation to processed medium characteristics, which, in its turn, constituents a serious challenge for domestic engineering workforce [2].

Precisely, it is a well-known fact that:

- production engineers do not know about the advances in the machinery being used, effective modes of equipment application, and physical bases of the processes;
- machine operators have no enough knowledge in chemical, microbiological, fermentative and other aspects of the discussed production;
- production staff do not demonstrate deep and systemic knowledge of production processes, and, sometimes, they have no relevant education.

Such deficiencies in staff education impede complex understanding of the product including knowledge of product's physico-chemical parameters and organoleptic properties. Even if the employees have enough experience in the relevant industry, nevertheless, they are not able to solve the problems independently and carry out complicated operating procedures, as they have no managerial skills and competences in economics. This fact usually leads to technical mistakes and ineffective product marketing strategy.

To provide a way out of this vicious cycle, the enterprises need to build a team which would be made of engineers, production engineers, and marketing managers [10]. It is such a team that could effectively address the tasks related to product design, production, and sales. It is worth noting that it is not only essential to design original food product, but also to preserve its specific properties for a consumer, i.e. end product marketing must be of thorough consideration in order to transfer innovative idea into fast-growing business [9].

Thus, it can be stated that technological infrastructure of enterprises directly correlates with the quality of engineering staff training. The trends in food industry development demonstrate a continuous increase in the degree of technological process complexity. Therefore, the enterprises increasingly need the specialists capable of operating modern and innovative facilities [2, 8].

Due to the 21st century economy and competitive environment, the role of an engineer has been significantly changed. A modern specialist has to act as technical expert, scientist, and manager, which dramatically expands his/her business and professional responsibility. The rapid change in technology and constant facilities renovation place increasingly high demands on basic education of the employees, their professional, intellectual, managerial, and personal skills. In this respect, it can be stated that traditional training methods and techniques do not meet the needs of high-tech industries for qualified graduates.

These contradictions become clearly visible when comparing modern educational standards (Federal Educational Standard) and real engineering training which is commonly based on the technological advances of the end of the 20th century. This lag has resulted in mismatch between employers' demands and graduates' competences, in other words, **engineering training does not address the complex challenges of modern engineering.** One more paradox of the Russian reality is also worth highlighting: decrease in quality of engineering training is accompanied by the increase in engineering students studying on the basis of state-commissioned education. Perhaps, for a certain category of students it is enough to obtain "any" diploma of Higher Education.

As a result, graduates have fewer opportunities to find a job in accordance with their education, and, thus, they have to work in other economic sectors [1]. The lack of high prestige for engineering professions and extremely low pay rates have resulted in dramatical changes of youth values – engineering professions, research work in Research and Development Institutes are no more attractive for modern school-leavers.

Thus, it can be stated that the level of modern engineers' knowledge constitutes a danger to the community in future and impedes technical development of the country at present. Therefore, it is required to reform national engineering education system. Under current conditions, higher education system should always be flexible towards social transformations and economic changes in order to avoid graduating "Bachelors and Masters of Emptiness". It is obvious that the past engineering educational system is no longer effective, since the market is searching for engineers-innovators and high-tech inventors. The holders of a master's degree are only those who are able to meet these requirements as their professional activity is basically aimed at scientific, technological, aconomic, and social progress of the community, as well as characteristic features of science-driven industries themselves [6].

Master's programs are a part of elite professional training which is intended for 15-20% of bachelor's degree holders. As the Bachelor-Master education system is not uniform, the content of master's education programs is determined by the university itself in accordance with the scientific interests of the leading faculty members (professors). It is explained by the fact that master's training is primarily based on the research carried out by faculty members, as well as required facilities of graduating departments.

To address the issue, it is required to transform engineering training from "qualification" basis to "competence" one, since the competence-based approach is the only way to ensure high quality of education. The main goal is development of key competences that graduates should attain in order to solve their professional tasks. First of all, a graduate must be capable of working with information, i.e. to know algorithms, data searching and processing techniques. To acquire these competences, a wide range of software products should be applied within engineering training programs. The knowledge of software products might be an extra bonus for a future employer. When it is impossible to apply a traditional approach to problem solving, an engineer should be able to suggest nontrivial solution, i.e. creativity – the second key competence for a graduate to acquire. Finally, an engineer should possess relevant social and personal qualities that are required to work effectively in a team framework including the ability to lead a team, especially in a highly ambiguous, uncertain and unpredictable environment, and assume the responsibility for the entire team and project implementation [9].

However, to introduce a competence-based approach into engineering education, it is essential to address a number of challenges, such as development of the relevant evaluation criteria and knowledge assessment methods, unwillingness of the faculty members to revise education programs, poor understanding of the two-tiered engineering education system [8].

Lack of facilities at universities is another problem that merits closer consideration. The high quality of engineering education is primarily dependent on the availability of up-to-date lab facilities and equipment which are an obligatory part of **practice-oriented training.** Within the practice-oriented approach, students have opportunities to engage in a variety of the relevant practice-related experiences. In this regard, the university should become a center of region's innovation activity incorporating various innovative research and training departments which would allow university to integrate education programs into a real sector of economy in order to find the solutions for a number of regional social and economic problems. Besides, such kind of education system will guarantee continuing professional development of all faculty members including the possibility to work with up-to-date facilities and equipment. Engineering training must be provided with due regard to technological advances and relevant modern inventions, otherwise universities continue to train "the lost generation" of engineers [1].

It is a well-known fact that the universities, which are under commission of the Federal Fishery Agency, train the engineers for fish-processing industry within the education programs "Production Machines and Facilities" (specialization "Machines and apparatus of food industries"). This program covers the entire range of machines and facilities applied in the food industry, with no focus being made on the advanced study of modern production processes, technologies and equipment which are of great value among the "fishery" regions of Russia [3]. In addition, modern production conditions, especially within medium and small-sized business, place increasingly high demands on the quality of engineering education. Therefore, it can be stated that today the graduates who possess relevant professional skills are of significant value. It means that universities should train not an "abstract" engineer, but an engineer of the next generation, an engineer who will suit to a definite industry, for example, refrigerating engineer capable of operating industrial cooling and refrigerating equipment.

In this respect, according to the Federal Fishery Agency task, Far Eastern State Technical Fisheries University has developed bachelor's/master's degree program "Production Facilities and Technological Processes of Fish-Processing Industries" in order to train engineers for hydrobionts processing [5]. The program was developed by leading faculty members of Far Eastern State Technical Fisheries University, particularly the faculty of Production Machines and Facilities Department (head of the department, PhD in Technical Science, Associate Professor T.I. Tkachenko, PhD in Chemicstry, Associate Professor O.V. Kuznetsova, PhD in Technical Science, Senior Lecturer V.A. Spolokhova), as well as the faculty of other universities commissioned by the Federal Fishery Agency including:

- Yu.A. Fatykhov, head of Food and Refrigerating Machinery department, DSc in Technical Sciences, Professor, Kaliningrad State Technical University;

- V.A. Pokholchenko, head of Processing and Refrigerating Equipment department, PhD in Technical Sciences, Associate Professor, Murmansk State Technical University.

S.A. Bredikhin, head of Production facilities and Industry Processes department, DSc in Technical Sciences, Professor of Moscow State University of Food Production, was directly involved in program development. The program was revised by the following experts: V.A. Grokhovskiy, head of Food Production Technology department, DSc in Technical Sciences, Professor, Murmansk State Technical University; V.N. Erlikhman, dean of Mechanics and Technology Faculty, DSc in Technical Sciences, Professor of Food and Refrigerating Machinery Department, Kaliningrad State Technical University. Thus, it can be stated that the leading faculty members of the most well-known fishery universities of the country have been involved in the education program development.

In accordance with the developed program learning outcomes, a graduate should demonstrate the skills necessary for research, design, production, energy-efficient and environmental friendly activities. The focus of graduates' professional interests is on **professional engineering**, i.e. the combination of engineering science and engineering management [2]. The essence of the process engineering correlates with the characteristic features of the post-industrial society and is based on the knowledge of production management, different technological processes and machineries, physical phenomena of energy and mass transfer, chemical, biotechnical, and microbiological transformations, as well as fundamentals of heat-and-mass transfer, physical chemistry, and mechanics. The integrated knowledge in the peculiarities of these processes is the basis for effective professional activity within the fish-processing industry.

цессного инжиниринга соответству-ет посThe basic stages of engineering are as follows: research, product design, production, development of product business projects. This means that a modern engineer should demonstrate not only deep knowledge in his/her profession, but also in scientific issues, economic, environmental, social and other problems of the community. A great variety of competences is due to the fact that a well-educated specialist is able to work more effectively in comparison with single discipline experts.

The process engineering is aimed at effective production management, technological process improvement, quality enhancement of end products, and technological effect achievement. Interdisciplinary experience and knowledge in relation to technological and managerial tasks allow engineers to reveal the limitations of the production system, eliminate the disadvantages of production process and go ahead towards the promotion of high-tech products, which, in its turn, will contribute to enterprise competitiveness.

It is obvious that modern engineering education should not lag behind the industry, but must be ahead of time. This means that education programs should be intended not only to cover the real technological issues and processes, but also to teach students how to predict the changes in production technology [8]. To achieve this, it is necessary to know and understand the problems faced by food production industry, and be able to solve them in the course of enterprise development. Therefore, the focus of the developed education program was made on shaping students' competence in science by introducing students to the fundamentals of analysis, calculation and design of technological processes and machineries of the fish-processing industries [5].

Upon the program completion, graduates must be able to use automated engineering design tools, demonstrate knowledge in system quality management, be capable of conducting marketing research, searching for optimal solutions in product design and manufacture with due regard to environmental safety. Thus, the content of education program reflects the basic international trends in development of hydrobiont processing industries.

In addition, the program was developed in accordance with the modern requirements towards fish-processing industry management, quality management, and technological infrastructure. One of the learning outcomes is the ability to make a wide range of decisions. Since the rate of fish-processing industry development is defined by rate of technical advance and consumer's market changes, a modern engineer should demonstrate not only creativity, but also willingness to continuous self-development [3]. Therefore, the proposed education program is of high quality and its graduates have sufficient knowledge and skills for successful career within high-tech business.

The graduates of the developed education program "Production Facilities and Technological Processes of Fish-Processing Industries" must be able to modernize the technological infrastructure of the fish-processing companies in order to ensure complex use of raw material, high quality of end products, enterprise cost efficiency and environmental safety. Being adapted to the current realities, the program is offered by all the universities which are under commission of the Federal Fishery Agency.

In conclusion, it should be noted that it is due to scientific innovations the industry can function effectively within a highly competitive environment. In that connection, there must be a clear understanding that **there is no alternative and there is no unique solution for the Russian Federation.** In recent years, low quality of domestic products and economic failure of many processing industries have been resulted from the limited use of international experience and practice. Global trends in processing industry development demonstrate continuous increase in the level of technological process and system complexity, therefore, the issues related to effective production management, product design, scientific and innovation activities, as well as lab research, are the bases for adequate solutions and company's success at the market. Today, fish-processing industry should become one of the leading sectors of the country's economy, and in order to remain competitive it should be based on science-intensive technologies.

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# On the Key Problem of Engineering Education in Machine-Tool Industry

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**The article considers the necessity and opportunity to develop a system mechanism model as an academic process reorganization basis for engineer training in the machine-tool industry.**

**Key words:** mechanism, function, structure, subject of apprenticeship research.

During many years of education reforms experts in philosophy, psychology, pedagogy, information did great amount of work on principle issue of educational methods and techniques in our country including – engineer professional training. However, broad debates on the issues of engineering education virtually leave open the questions of its **professional content.** It is impossible to educate a specialist outside the limits of professional expertise and this or that subject area in the engineering industry. Besides, content and arrangement of teaching material, intensity and quality of academic process, as well as anticipating character of an engineer training should be defined. In the condition of modern cognitive technique application the basis for educational framework is the modern knowledge system in the industry.

In the content of engineering knowledge of any sphere one can distinguish two main constituents: an engineering facility of the industry (in machine tool industry at the initial stages it is a mechanism) and **process** of its development. The effectiveness of engineer professional training is defined, first of all, by content and structure of basic ideas of the study object, i.e. **accepted original model** of the object. The accepted knowledge model of engineering facility defines **the subject** of the educational process in engineering training [1].

The stage of original model development and knowledge in some engineering spheres accumulated today can be divided into sufficient time period. During the harmonious process of engineering development its achievements can be applied (under the condition of feedback) to correct continuously the initial concepts. In real engineering knowledge development processes there is no such correction. Obsolescence of basic assumptions on the object, their inconsistency with potential modern cognitive and information techniques is typical, to some extent, for all industry branches depending on their age. Machine-tool industry is one of the oldest engineering branches, hence, it is particularly illustrative.

In Russia key assumptions about machines and mechanisms have developed on their disciplinary base by the end of the 19th century. At the initial stage such fundamental disciplines of professional education as following were chosen: “Descriptive Geometry and Graphics”, “Theoretical Mechanics”, “Material Resistance”, “Theory of Mechanisms and Machines” “Machine Parts”, “Material Science” and others. At the initial stage of engineering education development theory issues were of particular importance. The theoretical bases of courses were taught to develop abstract thinking of future specialists. During the further development, engineering knowledge itself was improved and new disciplines appeared. For example, “Limits and Fits” is a discipline dealing with issues of part size precision, as well as disciplines associated with friction issues. There are a lot of other examples. A long-term tendency towards development of applied industrial science emerged [2] at the turn of 19th-20th century. During the subsequent development stages (in accordance with the international tendency of scientists' growing pragmatism [3] or economy-centralization [4]) the engineering knowledge enhanced mainly due to private research results of separate research projects. The objective of **knowledge system** development was not set for engineering science. At the moment, knowledge of mechanisms and machines involves mainly specific, poorly ordered information. The amount of information is like a snowball. In this conditions, the knowledge systematization, their scientific structuring has become a challenging education problem. Today, this common problem is formulated narrowly as a problem of overcoming interdisciplinary limits. In addition, it is the disciplinary knowledge developed over the years that was taken as a basis for the existing education standards in the machine-tool industry regulating the content of engineers' training (for example, [5]).

A narrower statement of a general problem leads to attempts of private solutions. For example, the textbooks of general professional disciplines: "Theoretical Mechanics", "Material Resistance", and "Machine Parts" are formally united under one cover with the title "Engineering Mechanics" [6]. In this case, separate disciplines are considered as parts of one textbook. The manual of the same title [7] consists of such chapters as: "Basis of Mechanisms and Machine Theory", "Material Resistance" and "Machine Parts and Basis of Design". At present, the issues of machine, mechanism and their parts precision are dealt with in a special discipline without connection with the issues of mechanism maintenance. For example, in the textbook "Metrology, Standardization and Certification" [8]. In this book the chapter dealing with issues of mechanism precision is referred to as "Basis of Interchangeability". Such a title reflects the conditions of the first five-year plans, when interchange was the key requirement to unit precision in the mass production development during the industrialization stage. Modern system knowledge suggests functional-structural models of engineering devices, the precision of which is one of permanent and significant features of mechanism's operation. Since the error of hundredth or thousandth of millimeter can result in the destruction of a whole mechanism, the priority task of precision science in machine-tool industry is optimal (from the standpoint of mechanism operation and economy) standards for parameters precision of parts in device design. To overcome the interdisciplinary limits it was suggested [9] to unite informally (with development of common concepts) two interconnected content disciplines "Theory of Mechanisms and Machines" and "Machine Parts" into the course "Theoretical Basis of Machine-tool Engineering". Such a decision could be considered as a half-measure, however, excluding possible solution of the problem in general, although it involves definite expenditures and time. The opportunity of synergetic is also taken into account (for example, [10]) to develop the knowledge structure in education. However, such a modern approach does not eliminate the problem of a more in-depth study in objects at the level of logical thinking intertwining with the development of learners' cognitive abilities.

In the chapter "Necessity to review the content of general scientific and general engineering disciplines" [11] the lagging of basic assumption from the modern practice, particularly in student design-engineering training is pointed out. In work [12] it is noted that in the existing education standards the matrix of specialist competence correspondence to the sections of training material is based on initial disciplinary structure of knowledge. But in the correspondence matrix the competences themselves are developed randomly, without task-oriented and consistent organization of the academic process. The author suggests abandoning the correspondence matrix and taking activity-based logic of academic process organization as a basis for the educational content. One can also notice that the division of competences and development of interdisciplinary modules accepted in standards increase the degree of randomness in the content and organization of academic process itself.

The division of basic assumptions on mechanisms and machines into definite disciplines leads to the fact that the **conceptual framework** of the branch has not formed yet. It means that the **subject** of academic process in machine tool industry has not been defined as an integrated whole and there is no integrated model of mechanism at present. In these conditions a student is given a chance to grow an integrated "tree" of assumption in the profession [1]. That task was not coped with by the whole branch science in machine-tool industry up to the moment.

In such circumstances, it is obvious that one needs to return to the beginning of science and review the basic assumptions on **an object** in the branch from the point of view of modern opportunities for its determination. In this case, the primary target of reorganization in professional academic process can be considered the development of the modern mechanism model. General necessity of new reality model development more corresponding to the potentials of modern cognitive and information technologies is underlined in the science about information, i.e. informatics [13].

The task of integrated mechanism model development is described in [14]. As a result of research, a functional-structural (system) model of mechanism is proposed, and, on its basis, a scheme of academic process of a fundamental course "Principles of Mechanism Construction and Operation".

The functional-structural model deals with a mechanism as a system of contact chains of part interactions performing its functions. The main functional chain in mechanism connecting its input and output, as well as sequence of derived functional chains of different order, forms an integrated structure. Any chain or its link can be considered on the basis of models of different completeness: size, static, kinematic, dynamic, and stochastic. Besides, an integrated operating structure can be revealed as a "mechanism-part-surface" chain to determine the principle scheme of parts and surface operation in-situ. The idea of "mechanism-part-surface" chain is consistent with the concept of integrated error of mechanism accepted in [15].

Based on the accepted system mechanism model, the sections of training material on fundamental course are designed in accordance with structural groups of the system. Since the first days of study at university a student is suggested one practical research project of mechanism structure (using virtual prototypes, carton board models, 3D-images). Such an arrangement of training material provides a student with an opportunity to observe the field of professional knowledge in general event at the initial training stage. Besides, students are taught to define practical problems of the subsequent order.

In academic process the research in solids interactions in mechanisms can be added by the study in interactions of solids with liquids, gases, granular, etc. in machines in the framework of general structure. Such an addition allows the subsequent transition from mechanism model to more complicated machine model. The **process** of machine design and operation (construction and engineering design, production, testing, operation) is proposed to be studied in terms of the order of accepted real procedure. The stages and procedures of this process are to be forestalled by the necessary and sufficient theoretical justification. Such a parallel connection of theory and practice enables a deeper understanding the concept of procedures and intensification in the academic process.

The accepted system of assumptions allows a thorough structural analysis of mechanism, i.e. the links of any part surface with the surface of another part, and, above all, with the mechanism function. Today, such potentials in machine tool industry are estimated by some experts as redundant – in practice, this branch has developed a wide range of template solutions for design and engineering conditions. However, from the standpoint of knowledge arrangement and formalization as well as application of information technologies, the accepted assumptions provide significantly new opportunities in machine-tool practice. In particular, to justify the optimal standards of part size precision, the development of module technologies are based on template operational part structures and their surfaces, etc.

Mechanism functional-structural scheme can also serve as a basis for academic process improvement in machine-tool engineer training. The scheme of academic process suggested in [14] includes hands-on professional experience from the first day of study in university, not academic, but practical professional training and organic solutions of most problems in branch professional education: practice-oriented, problem-oriented, developing, advance training, and a number of other requirements for modern academic process.

The author is fully aware of the fact that actual system organization of the academic process requires involvement of many independent experts of different fields. First of all, it is necessary to discuss potentials and versions of suggested model in the professional community involved in the academic process. In the author's opinion, such an appropriate community, can include university teaching staff attending upgrading courses. The advantage of such an "educational board" is the involvement of a wide range of experienced professionals and their qualified view on the problem. Relative independence of teachers-researchers from their management and dictation of authorities is also of great importance. Taking into account amended corrections and comments it will be possible to arrange the academic process for several pilot groups within the leading universities of the country at the initial stage of transformations.

Therefore, it can be concluded that

- The key problem at the modern stage of professional education reforms in the machine-tool industry is to define a subject of academic process in the branch – development of modern system mechanism model.
- Probable system organization of academic process can serve as a basis for the solution of most mentioned problems of reforming professional education in the branch (at all its levels).
- Quality of basic object model in the branch is associated with the opportunities in the of information technologies in the branch, ecology of knowledge, as well as saving students' and working specialists' intellectual labor.







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# The Imperative of Engineering Staff's Intellectualization and Common Culture Enhancement

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**The causes for stifling innovation in the country, reduction of the engineers' overall culture and quality of their training have been analyzed. The ways of the future engineer's personality development on the basis of domestic experience and modern TIPS tools are considered.**

**Key words:** critical technologies, invention, intelligent property, solution of nonstandard problems, the integrity of a person, a common culture, «official» and «unofficial» education, experience of engineers' training in Russia, the TIPS tools, knowledge transfer.

There is a demand for "new industrialization" in Russia, which is closely related to drastic improvement in engineers' training. The tasks set for engineers of our country are rather serious. To understand this, it is enough to look at the list of critical technologies (Table 1).

Whereas in 1996 their list included 70 items grouped in 7 units (information technologies and electronics, production technologies, new materials and chemicals, living organisms' technologies, transport, fuel and energy, ecology and environmental management), by 2002 it has contained 52 items grouped in alphabetical order. In 2006 the list was reduced to 34 items, but the list of 2008was added with the item "Production technologies of metals and alloys with specific properties used in weapon and equipment production". Later, in 2011 the priorities became 8 items: safety and counter-terrorism; nanosystem industry; information and communication systems; life sciences; promising types of armament, military and special equipment; environmental management; transportation and space systems; energy efficiency and conservation, nuclear energy. The number of technologies reached its minimum – 27, the list included cognitive technologies for the first time.

Then, in 2012 the list grew again to 38 items. Technologies of information collection, retrieving, storage, possessing, accessing, and protection were classified separately. By 2013 the list was added with the following items: cryobiological technologies; development and production of immunobiological medicines; tissue, cell reproduction technologies in medicine and veterinary; genetic technologies.

The analysis of the changes leads to the following conclusions:

1) there are no electronics, production and aviation technologies; ecology, nanomaterials, new materials and chemical engineering are among the priorities;

2) number 1 is the item «Safety and counter-terrorism»;

3) high frequency of changes in the list and superficial priorities are noticeable. However, the major point is wide coverage of the list under the condition of limited financial resources. The priorities are updated in our country in the same way as changes are introduced in the form of reforms. In this way there are mergers of state-owned corporations, ministries, management bodies, but inadequate decisions do not improve the work of merged departments [1].

Public activities in the sphere of critical technologies reflect like a mirror the conditions of innovation policy. Its results are disappointing – the share of Russian innovative products in the international







**Table 1. The years of adoption of critical technologies (CT) list**

| | Years | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1996 | 2002 | 2006 | 2008 | 2011 | 2012 | 2013 |
| The number of CT | 70 | 52 | 34 | 35 | 27 | 38 | 42 |
| № of the document, a body adopted it, date | Order of the RF Government of 12 July, 1996 2728p-P8 | Order of the RF President of 30 March, 2002 Pr-578 | Order of the RF President of 21 May, 2006 Pr-842 | Order of the RF Government of 25 August, 2008 1243-r | Order of the RF President of 7 July, 2011 № 899 | Order of the RF Government of 14 June, 2012 № 1273-r | Order of the RF Government of 24 June, 2013 № 1059-r |

market has not grown over the past decade and amounts 0.2-0.3% [2]. A clear indicator of "resource" development is absence of federal law on innovative activity in the country. Under those conditions it is natural that research-engineering staff is not in demand in Russia. At present, during the period of world economy crisis, collapse of oil prices, and complex economic-political situation around Russia, it is hoped for drawing authorities' attention towards inno-vations, in general, and engineering activity, in particular.

There is a proverb: "A good student is a good engineer, a bad student is a chief engineer". It presents the results of different trends in mind training: the first is focused on diligence, the second – decision taking in the condition of uncertainty. Forced "to merge" (when and where it is necessary) the "broken" pieces of knowledge into relative integrity, an inventive student, a truant, often appears to be more adaptive to the present every-day and working circumstances, where the necessary information is not always available.

It leads to awareness in importance of "harmonization of moderate professionalism and moderate dilettantism" in a person's professional development, as well as "harmonization of moderate socialization and moderate autonomy" in one's public life [3] as a fundamental program. One can support the idea by K. Marx "on professional snobbishness and professional cretinism" of specialists as well as B. Shaw's words about the fact that "narrow-focused specialist knows more and more about less and less things until he knows everything about nothing and nothing about everything".

When developing TIPS, G.S. Al'tshuller suggested his classification of problems corresponding to five levels of inventions (from small to pioneer ones) [4]. It was proved: to develop inventions of the first level it is enough to have special knowledge in the professional sphere. In fact, it means to find useful engineering solutions "missed" by other specialists. Those solutions are sometimes almost obvious. Every subsequent invention level (small, medium, large) is characterized by transcending the specialist's individual knowledge – into professional sphere in general, then – entry into interprofessional, and, in the long run, interdisciplinary spheres of knowledge. The level of non-obviousness for such solutions is growing. Their inventor has to search for the answer in the wide sphere of knowledge accumulated by mankind; it requires full development of personal potential.

The history of our country attests that the importance of harmonic development was not just accepted, it was a program concept. The program of the Communist party implied the solution of triune problem: in the sphere of economy – development of appropriate physical facilities for communism (taking the first place in production per capita, achievement of the highest productivity in the world and the highest people's living standards); in the social-political sphere – transition to communist self-government (new public relations); in the ideological sphere – shaping a harmonious personality.

It is known that in struggle for the victory in social competition the quantity was often more important than quality. It was also true about inventions. There was a practice of researchers' informal communication with the officials of Goskomizobreteniya, the latter could give advice to correct the application design – so that an inventor's certificate could be obtained. Therefore, the invention statistics in the USSR should be treated sensitively (Table 2). But even comparison of Soviet period data with the existing system of industry property (IP) patent in Russia is discouraging (Table 3).

Russia lags behind the developed countries in inventions. From 2000 to 2010 the number of patent applications in Russia grows 1.5 times – from 28.7 to 41.4 thous. (compare: at present, China and Hon Kong produces more than 520, USA – more than 500, Japan – more than 340, and South Korea – about 180 thous. of applications per year). The analysis of growth (in terms of Rospatent annual reports) shows the outstripping growth in foreign inventors' applications. The patent applications of Russian inventor increased by 13% within this period, whereas those of foreign ones – 2.8 times, which is a visible indicator of growth in investors' and producers' interest in Russian market.

Patent dynamics is a good illustration of the country's economic life. The number of applications (Table 3) in 2013 as compared to 1988 had fallen 3.9 times. Taking into account that in the USSR most inventors' applications were made by domestic applicants, this difference amounted 6 times. In comparison with the present-day inventions (about one-third of them) the number of utility model application has grown, which is a clear indication of decrease in intellectual capacity of solutions developed in applications (to

**Table 2. Dynamics of inventions in the USSR over 1975–1988 [5, p.25]**

| Key indicators | Years | | | |
|---|---|---|---|---|
| | 1975 | 1980 | 1985 | 1988 |
| Inventors' applications in Goskonizobreteniya, thous. | 119.2 | 168.6 | 168.0 | 174.7 |
| Registered inventions, thous. | 44.1 | 94.6 | 74.6 | 84.0 |
| Innovation proposal (IP) applications, thous. | 4910.8 | 4758.8 | 4883.4 | 3996.9 |
| The number of accepted innovation proposals (IP), thous. | 4489.6 | 4529.3 | 4678.7 | 4018.1 |
| The number of applied inventions and IP, thous. | 3977.4 | 4048.0 | 4059.8 | 3419.4 |
| inc. inventions | 14.9 | 24.1 | 25.1 | 22.3 |
| The authors of inventions and IP, thous. | 4335.8 | 4650.3 | 4705.5 | 3982.8 |



**Table 3. Dynamics of IP* applications in Russia**

| Type | Application to Rospatent per years | | | | | |
|---|---|---|---|---|---|---|
| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
| Inventions | 41849 | 38564 | 42500 | 41414 | 44211 | 44914 |
| inc. Russian applicants | 27712 | 25598 | 28722 | 26495 | 28701 | 28765 |
| Utility model | 10995 | 11153 | 12262 | 13241 | 14069 | 14358 |
| inc. Russian applicants | 10483 | 10728 | 11757 | 12584 | 13479 | 13589 |
| Design solution | 4711 | 3740 | 3997 | 4197 | 4640 | 4994 |
| inc. Russian applicants | 2356 | 1972 | 1981 | 1913 | 1928 | 1902 |
| TM** registration | 57112 | 50107 | 56848 | 59717 | 61923 | 64928 |
| inc. Russian applicants | 30024 | 26448 | 32735 | 33252 | 34851 | 34621 |
| PDO*** registration | 35 | 30 | 63 | 58 | 66 | 39 |
| inc. Russian applicants | 31 | 27 | 56 | 58 | 61 | 28 |
| Total: | 114702 | 103594 | 115670 | 118627 | 124909 | 129233 |

Note: IP*– industrial property,
**TM – trademark, ***PDO – protected designation of origin

issue a patent for them it is not required to achieve the invention level). At the moment, in Russia there are only 1.6 thous. of patent attorneys as compared to 3,1 – in Germany, 10,1 – in Japan and more than 40 – in the US. In addition, the distribution of attorneys over Russia is uneven – 90% of them work in Central, North-Western, and Volga federal districts.

As for the role of cultural development for a man L.S. Vygotskiy argued that he equates a child's personality with his/her cultural development. It is a key aspect forming a personality's integrity. In philosophy the problem of "integral" person is one of the most important. According to M.K. Madardashvili, "a human being is dissipated in thousands of vessels, which are not linked with each other, – a human being is broken into different locations in space and time" [6].

It is known that every year substantial knowledge acquired by a man in the course of "official" education (at school, then at university) decreases, whereas the share of "unofficial" or random "occasional" knowledge acquired in family, in the course of supplementary and distant learning is constantly growing. It has formed a tendency [7]. At present, the oldest and powerful educational institution, a family (with its capacity to give integral education and "informal" knowledge), has become of particular significance. Engineering training at university, in-service training or other further education are also essential for development of education integrity [8, p. 136]. The leading domestic scientists proved the necessity to intellectualize education via: its fundamentalization; noospherization, humanization, and creatization; use of culture; informatization and integration of educational and research processes [9]. The journal "Engineering education" has already considered the potentials of TIPS developments to solve engineering education problems. We can give the additional arguments in favour of solving the key problems of engineers' training based on TIPS and the theory of creative personality development – TCPD (Table 4).

Solving the problem of education intellectualization it is important to remember the experience of engineers' training in our country. The experts underline: a strong support of Russian engineering universities by the country leaders led to economic infrastructure breakthrough in Russia of the 19th century – the first half of the 20th. In the 1880's thanks to an outstanding engineer, and, subsequently, the Minister of Finance I.A. Vyshnegradskiy, the secondary and primary engineering education was reformed. The electroen-gineering institute in Saint-Petersburg and Technological institute in Kharkov were established.

Under the reign of Nicolay II the second wave in numerous establishments of engineering universities was observed. By the beginning of the First World War the system of higher professional engineering and agricultural education in Russia left behind the German one, which was achieved due to target policy and significant investments in this sphere beginning from the mid 1890's [8]. By 1917 the country had possessed the engineering potential of German level, exceeding France. The USSR inherited from the Russian empire the strong system of engineering education. By 1925 in the USSR, only one new higher technical institution (Moscow Mining Academy) had been established. All other were transformed from the previously existed or arranged on the basis of evacuated ones from Poland and Baltics. A number of new institutions (Moscow Institute of Mechanical Engineering, Mendeleev Chemical Technology Institute, Leningrad Institute of Fine Mechanics and Optics, Moscow Textile Institute and Kazan Polytechnic Institute) were established on the basis of large specialized secondary schools. In the periods of Revolution, Civil War and repressions against educated social strata, the country lost up to 80% of qualified teaching staff. But in the 1930's the Soviet government realized the danger of dropping in the education level and started to restore the educational traditions (first of all – in the sphere of natural science and engineering education). S.P. Timoshenko, who left the country during the Civil War and visited the USSR as early as 1958, underlines [13, p.10]: "… Russian returned almost completely to the educational system, which had existed before the Communist Revolution. The traditions of old school appeared to be very strong and by means of the rest of old teaching staff it was possible to put in order engineering education destroyed during the Revolution".

The history evidences the establishment of reliable models of engineering education. An engineer with higher education was simultaneously a researcher, technical expert, and production manager (Table 5). Such a training system implied not only "fostering of intellect" and fundamental academic qualification, but also "fostering of will" and managerial abilities. The gap between practice of engineer and manager is viewed by the researchers (from the standpoint of education) as a degradation phenomenon, which was avoided only by some educational institutions (for example, Massachusetts Institute of Technology) [8]. Collapse of the USSR, development of "privatization" economy and then "kickbacks" in Russia undetermined the prestige of engineering labour, which had a negative effect on the engineering education. Domestic mass media added fuel to the fire.

Here is the analysis of 525 top news in 2009 (from February to June) and 365 top news in 2010 (from December 2009 to the middle of March, 2010) [18]. The results (%) are rather illustrative (Table 6).

The character of modern engineering activity requires a return to complex model including two-system model (engineer-manager, engineer-economist, engineer-researcher, engineer-teacher, etc.), but on a new base. However, it needs to be deciphered. In this case, it is important to pay attention to the fact that majority of problems, including engineering ones, are solved by analogy. T. Edison stated on this







**Table 4. TIPS in terms of education intellectualization**

| № | Trends | Description and potentials in TIPS application |
|---|---|---|
| 1 | Fundamentalization and universalization | Cosmism and mathematization of knowledge, development of scientific worldview. TIPS are often called "applied dialectics", it generalizes the system of laws in system organization, functions, development. There are transfer algorithms of production processes into invention problems. To solve them, the resources of phys-, chemico-, geometry-, bio-, socio-, and psycho effects are used |
| 2 | Noospherization | Intellect has to be converted from "mind for itself" into noospheric-biospheric one. TIPS as a general theory of strong mind (GTSM) leads us to planetary thinking promoting "to think globally, but act locally" |
| 3 | Humanization | Requirement for intellectual integrity, morality, and spirituality. Development of synthetic intellect through Russian literature, Russian philosophy, Russian cosmism. TIPS tools work well in this sphere [10] |
| 4 | Creatization | Application of game technologies, development of creative environment, teaching creative life-long bases. In the course of TIPS acquisition a great number of game technologies are intensely used (for example, "yes-no" problems). There is a complex in "Development of creative imagination" [11] |
| 5 | Use of culture | Culture fosters intellect on the national-ethnical base, in language, national history. Without culture intellect is psychically instable. G.S. Al'tshuller developed the technique of writing phantasy (Register of scientific-fantastic ideas (RSFI), "Fantasy-2" scale. In TIPS pedagogy there is a number of approaches to TIPS and RSFI application in literature and language, history and music [12] |
| 6 | Informatization | It is often confused with education intellectualization. Using computer only at a user's level sometimes results in the opposite effect – deintellectualization. TIPS are supported by a number of products of "computer aided thinking" type. They were initiated by the project "Inventing machine". It is referred to artificial intellect |
| 7 | Integration of secondary educational and research processes | Learners' immersion into research process attunes to learning the world. Techniques of TIPS development through catalogue of tool statement and verification (techniques of technical conflict resolution, standards of invention problem solutions, laws of system development, etc.) are a vivid example of solving problem of education integration with exploratory research |

**Table 5. Characteristic of engineers' model development**

| № | Model | Comments |
|---|---|---|
| 1 | Engineer-manager of production (practice-oriented engineer) | In the Institute of Railway Engineers (IRWE) a student had to develop three projects (a bridge, sluice, steam engine), and in the course of internship he got experience in implementation of those projects. In the 19th century a lot of famous constructions (bridges and sluices) were built by the students together with their teachers. In summer students participated in construction work. In Saint-Petersburg Polytechnic College, one summer, a student-shipbuilder had internship in the port, the other – at machine building plant, the third – in sailing [8] |
| 2 | Engineer-economist | In the Institute of Professional Upgrading of Specialists the engineers' training as future leaders included large amount of economic knowledge. Engineering-economic and economic branches became independent later. In 1902 in Petersburg Polytechnic S.Yu. Vitte established the first Economic department. Whereas in commercial universities of Moscow and Kiev engineering departments were opened. The trend became international. In the USA engineering developed simultaneously with introduction of "management ideology". In the USSR the first graduation of engineers-economists (79 graduates) took place in 1927 at Industrial Department of Leningrad Institute of National Economy (earlier – Trade-Industrial Institute of M.V. Pobedinskiy) |
| 3 | Research engineer | The model of "phystech" was developed in 1916. (A.F. Yoffe and S.P. Timoshenko in Petersburg Polytechnic developed the project of physical-mechanical department, arranged a seminar (P.L. Kapitsa, N.N. Semenov were participants of the seminar). Thanks to P.L. Kapitsa, since 1919 Petersburg Polytechnic had trained engineer-researchers with unique qualification |
| 4 | Teacher engineer | The stages of professional-pedagogical education (PPE) [14]: "pre-systematic" (1865–1914); I stage (the 1920's – 1930's) – a network of institutions and merger attempt under Glavprofobr; their transfer to narkomats; phasing out institutes and colleges; II stage (from 1943 to the end of the 50's) – restoration of intermediate link in PPE – opening of industrial-pedagogical colleges (IPC); III stage (from the 60's to 1979) – organization of engineering-pedagogical departments (IPD) in polytechnic institutes; extension IPC network; IV stage (from 1979 to the beginning of the 90's) – establishment of specialized universities (Sverdlovsk Engineering-Pedagogical Institute, Kharkov Engineering-Pedagogical Institute), extension of IPD network in IPC; V stage (from 1991/92 to the present) – collapse of the all-Soviet system of PPE; in the RF – increase in the number of universities and colleges, qualifications of teachers for PPE and SPE (opening "non-engineering" specialties: "veterinarian-teacher", "economist-teacher"), since 1992/93 ac. year transfer to the multilevel system (Bachelor – Specialist – Master); standard introduction in 1996. HPE and SPE; in 2000 introduction of new classification of majors and specialties in HPE ("teacher of professional education" – for all types of specialty 030500 «Professional education» –19 of them) |



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issue: "If you want to invent perfect ideas, you should know: the best of them can be borrowed".

The world has accumulated a great amount of solutions, it is only necessary to find common, developed solutions and apply them to solve the other relevant problems. In patent sphere it is referred as "invention to use for a new purpose" (it is possible to use methods, devices, substances, microbial strain in this way). From the standpoint of inventions classification, such intellectual activity inevitably leads a solver beyond the bounds of professional knowledge (to the invention of 3-4 levels) requiring high common culture and wide worldview. The knowledge necessary for the use in other sphere can be found in quite unexpected place. As soon as the 1970's G.S. Al'tshuller described how students of public institute of engineering creativity (three students and a young engineer) chose a complicated problem for their diploma projects on aerial navigation. There had been attempts to solve it in several countries. Calculation was based on the fact that reliable solution had to lie outside the bounds of common ideas in navigation machine tool engineering. The required principle appeared to be found far from aviation area – in confectionary technology (!). The invention was awarded with experts' positive evaluation and the title of protection [4, p.18].

At present, similar intellectual activities form the basis for contemporary knowledge transfer [16]. Most solutions, developed by the foreign TIPS experts for the leading international companies, are performed in the same way [17]. Hence, it is hard to escape the conclusion that TIPS are a reliable base for transfer of innovations from one sphere of human activity to another in the theoretical-engineering aspect, which permits the transgression of inter-professional and interdisciplinary frameworks when solving a problem. Therefore, acquiring TIPS tools would solve the problem of engineering education intellectualization and enhancement of future engineers' common culture. The history evidences that great engineers of the past achieved a lot due to their high cultural standards [18]. We hope we would achieve the same.

**Table 6. Analysis of mass media news in Russia in 2009–2010**

| № | News | Years | |
|---|---|---|---|
| | | 2009 | 2010 |
| 1 | About achievements in nature studies | – | – |
| 2 | About engineering achievements | 0.5 | 1.9 |
| 3 | About well-doers | 1.0 | – |
| 4 | About Russia | 7.8 | 9.9 |
| 5 | International news | 12.4 | 11.0 |
| 6 | About wars, conflicts, terrorism | 5.0 | 8.0 |
| 7 | About crimes and criminals | 10.3 | 11.0 |
| 8 | About deaths, accidents, violence | 17.2 | 24.2 |
| 9 | About swine flue | 4.2 | – |
| 10 | Show-business | 20.3 | 19.6 |
| 11 | About nothing | 9.5 | 5.2 |
| 12 | Politicians' advertising | 11.3 | 9.2 |

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# Environmental Training and Education

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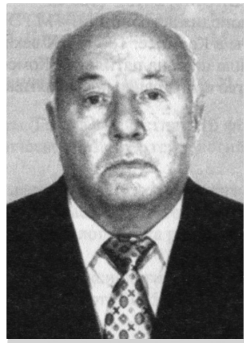

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**Article highlights issues of environmental training in secondary and higher education. Authors suggest universal formula of progressive education, which is targeted at unity and progressive development of Russia by means of environmental training. Current article is of conceptual kind and comprises different areas of environment.**

**Key words:** environmental education, environmental training in secondary and higher education, universal formula of progressive education and training.

In the modern world, education becomes an important process in development of social and economic progress. During ecological crisis the educational system is the source capable of forming human qualities such as love, kindness, respect, mercy, compassion for others and Nature. Such moral qualities of a person are needed to understand value of life, responsibility for life preservation and great «reverence» for life.

Absence of such set of values prevents from application of modern clean technologies and environmental friendliness. What is needed is the review of all main types of relations: relations between man and nature, relationship between man and man. The process of training in the educational system acquires new tasks.

Education is inextricably, harmoniously connected with training that is to say that education and training are united. Therefore, universal formula of progressive education and training is as follows:

**Progressive education and training form united harmoniously tightened process of formation of creative individuals with high level of knowledge, intelligence, patriotism and sports.** Therefore it is necessary to significantly accelerate the process of patriotic education in Russia; suppress any distortion of history; imply criminal responsibility for promotion of fascism and nationalism.

One of the main areas of patriotic training is the environmental training: love for the motherland, for our Nature, goodwill, mutual assistance, formation of ecological intelligence and many other positive qualities. All of them eventually should be targeted towards the ultimate goal – to strengthen unity and progressive development of Russia.

In Russia in 2009 Danilyuk A.Ya., Kondakov A.M. and Tishkov V.A. issued "Concept of spiritual and moral development and training of individuality of a Russian citizen". This particular concept formulates core value milestones, moral norms, ethical standards, which can unite youth into a single historical, cultural and social community during tough times of the country development.

However, training of modern youth in the Russian educational system is almost untouched [2].

At schools, gymnasiums and lyceums training mostly stands for observing discipline. In educational institutions results of monitoring, ratings are considered as important parameter; families appreciate the results and achievements expressed in high grades. Main affords of teachers and parents are targeted towards successful results of Uniform state exam which is a step to successful start in career.

Besides, according to the research of Yasvin V.A. only 15% of biology teachers consider environmental training as their main pedagogical task, when 66% are convinced that they have to stick to formation of biological knowledge. [9].

The situation in institutes and universities is similar. Higher school requires rapid acquisition of knowledge from young people and ability to apply them successfully in professional activities. Ethical education of students is almost not paid attention to [7].

According to Baidenko V.I. higher education should put stronger emphasis on strengthening ethical and moral aspects. The new approach is needed, the one which will shape "human" personality, lead to creative actions and responsibility for decisions made, raise spiritual and moral personality. Modern graduate of a higher educational institution or a student should not only be able to adapt quickly to new working conditions, but should have strong moral position [1].

However, in day to day life we observe how modern man constantly puts himself in fierce competition chasing for profit. The priority of profit, consumer attitude to each other is not just a feature of a modern student but a feature of an adult.

Thus, we can conclude that systems of secondary and higher education systems are focused on high ratings, when no one pays attention on formation of highly spiritual personality, making it responsibility of a family. The ethical component of decisions made is not of the interest of majority.

Analysis of scientific sources (Novikova A.M., Stepanova P.V., Zimnyaya I.A., Yasvina V.A.) has reviled a number of complex and controversial issues in the aspect of training. According to Zimnyaya I.A. there is no training strategy in lifelong learning in Russia. It is currently under development. [3, p. 70-79]. Training aspect was studied by Babochkin P.I., Bondarevskaya E.V., Korotov V.M., Lisovskii V.T., Likhavech B.T., Novikova I.I., Rozhkov M.I., Selivanova N.L., Talanchyuk N.M. and others [3,6].

We believe that ecology, which holds one of the most important positions in current educational system, can be the solution as it contains strong educational function. Teaching ecology aims to increase the level of moral rights, to create new world-view, form critical and reflective thinking in respect of life and any person and the World based on the principle of «Reverence for life» of A. Schweitzer and the «Earth ethic» of A. Leopold.

According to Totai A.V. the aim of the environmental training is in formation of responsible attitude towards environment, which is based on ecological conscienceness. It implies observance of moral and legal principles of management of natural resources and active actions focused on education and preservation of the local nature [8, p. 329].

Teach students to see the beauty of Mother Nature, cherish and love it are the main tasks of any teacher. These are love and respect for the native land, small motherland which have been always a powerful resource, a reserve for development, for formation of spirituality and morality of a man. For many great writers, poets, composers, artists, scientists it is typical to show reverent attitude and praise the beauty of nature. It contributed to their spiritual formation and inspired them for many great works.

Thus, environmental education which lays the foundation of humane attitude towards nature has paramount importance in formation of highly moral attitude towards nature for the person [5]. In this particular aspect leading role is given to the natural science, as it has actual links with the study of nature, living organisms and man.

Department environmental geology was opened in the Ural State Mining University in 2010. It has the new for the region educational program "Management of the environment and natural resources". One of the top priorities of the department is formation of moral principles and improvement of environmental culture of students. Manual "Environmental geology" and courseware "Study of biosphere", "Soils", "Social ecology" were published at the department. They all have elements of eco-axiological approach and based on original studies of eco-philosophers Vernadskii V.I., Schweitzer A.L., Chizhevskii A.L., Reimers N.F.

In line with the development of eco-axiological world-view of the youth field training "Biodiversity and general ecology with the elements of soil science" is held on the Nature Park "Bazhovskie mesta" in order to form respect for the nature of the Motherland. It includes studying of soils, flora, fauna, surface and underground hydrosphere.

Nature Park "Bazhovskie mesta" is the natural area of preferential protection of the regional level. According to the regulations, natural parks are environmental, ecological and educational and research institutions, their territory (water area) includes natural complexes and objects having special ecological, historical and aesthetic value, and they are intended for use in environmental, educational, scientific and cultural purposes.

Within the field training in order to study the environmental characteristics of the Nature Park students conducted research on biodiversity. Students became familiar with various methods of catching small mammals and insects (mowing method, trapping grooves), the collection of non-flying insects. During laboratory works students determined species and systematic affiliation as well as demographic characteristics of mammals, rodents, amphibians and made collections of insects. During each class you could observe how enthusiastic and inspired were both students and teachers learning something new about the nature and wildlife. But the most important and valuable observation about the students is the emergence of desire to know the nature of the native land.

In the suburbs of the Nature Park "Bazhovskie mesta" students have found population of gray heron. Students defined basic characteristics of the species, ecology, food and social activity. After long observation of birds they formulated a scope of measures needed for the preservation of the population: reduction of the penetration of urbanization, prohibition of logging in order to preserve habitats, promotion of the necessity to protect the species.

Further students proceeded with the study of the Talc Stone Lake. Students learned the history of the lake, notified its beauty, uniqueness of "Bazhovskie mesta". They studied characteristics of meadow, forest, floodplain and anthropogenic types of plants. Students learned how to collect medicinal herbs and properly make herbarium.

Large populations of rare species of plants were found in that area. Students studied, counted, measured and characterized rare species listed in the Red Book of the Sverdlovsk region [4]. Current activity helped to form individual responsibility of each student for preservation of each species.

With the understanding of the importance of research and educational practice students were more responsible in studying of nature (flora, fauna, chemical composition of soil types, surface and groundwater). Participants set the effect of anthropogenic load on the condition of natural complexes and studied reduction potential of wildlife.

Based on results of the research backed by the theoretical studies of Vernadskii V.I., Schweitzer A. et al. students could once again assure themselves in the complexity of interactions of all components of ecological systems in the Nature Park "Bazhovskie mesta", they perceived nature as integrated system with interdependency of all components.

In parallel with the study of methods, there were conditions favorable for formation of human features such as ethics, responsibility, caring and sensitive attitude to nature and others, to any living creature. On the basis of the real facts students faced the revaluation of the abilities of nature and the place of a man. Moral interpretation of inextricable links with nature made all the participants feel responsibility for its preservation.

Educational field training in Nature Park "Bazhovskie mesta" has great potential and opportunities for educating a man cherishing nature of the native land.

Findings lead to understanding of the interdependence of man and all inhabitants of ecosystem. Man is a part of the complex system – the Nature. Such environmentally friendly world-view makes young people more responsible towards nature and any form of life.

Following these principles the course is based on the concept that man and nature are interrelated elements of the Earth. Man acts primarily as a spiritual and moral being who is responsible for all further activities, attitude towards other people, animals and plants of his native land.

Prospects of further actions should be targeted at:

1. Expending quality and quantity of environmental studies.
2. Enhancing environmental training in educational systems.
3. Creating environmental brigades at the universities and schools with the view to the acting construction brigades. Particular attention should be paid to stimulation of environmental intelligence.
4. Forming a man with the "reverence" for life.

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UDC 378

# Learning Factories: The Way to Create World Class Graduates Through Engineering Education

The Private High School of Engineering and Technologies Tunis, Tunisia
**Z.C. Chagra, I. Shimi**

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I. Shimi

**The learning factory can be defined as a type of university – factory (or professional institution or company) that aims to produce better generations of students and make them more ready to market. This paper describes a model of learning factory made at Esprit School of Engineering, Tunis, Tunisia. This paper shows also the specifications of this experience as it is held at in an institution already facing major changes in its curriculum due to following active learning educational approach.**

**Key words:** active learning, learning factory, educational programs modernization, education engineering, software engineering.

## I. THE IDEA

Esprit School of Engineering follows the PBL approach: Project/Problem Based Learning in its courses for its different fields. The main aim of this adopting this student-centered education approach is to guarantee a better results of employability shaping a ready-to-market engineer profiles. The idea came to follow the Learning Factory model at several universities in the world to be the next step after the basic three years of Project Based Learning: Esprit learning factory saw the light in late 2014 to be a space where the student lives the transition from his university to the professional world. Esprit learning factory is acknowledged after analyzing the trending and similar experiences aiming to provide the best transitional environment for the graduate students with the supervision of IT companies and partners.

This paper will mainly present this educational experience as a new experience for the educational and professional field in Tunisia. It specifies this experience and the main basis with a first analysis of the industry and faculty needs and expectations.

## II. THE CONTEXT

As the main objectives of a learning factory at Esprit are essentially about shaping ready-to-market engineer profiles in relation with the main project about adopting the active learning pedagogic approach, the need of understanding the context of such an experience remains vital to determine the way of establishing a learning factory. It is essential to know about the needs from the viewpoint of the industry and of the faculty.

- The industry seeks to raise its profits by accelerating the integration of newly hired engineers. The industry seeks for the engineer who applies the fundamentals and integrates the industry to be a productive. In addition, the specific case of IT, implies to be adapted to the new markets and technologies as soon as it appears.
- □ The Faculty, in the other hand, in interested in the measurement of its quality of students, professors and its curriculum simultaneously to shape the perfect profile for national and international accreditation, and therefore distinction. Adopting an active learning pedagogic approach aims to make the faculty more and more active following a student-centered approach implying an active educative environment (updated

courses, a multitude of scientific papers and conferences).

### III. THE LEARNING FACTORY: A WAY TO GET TO THE MARKET BEFORE GRADUATION

Esprit learning factory is established in a whole building which is composed by companies and startups following a practice-based curriculum in order to integrate Esprit graduates into the professional world. The graduates are mentored by their professors in collaboration with the company. This creates an interactive environment in which the graduate student finds the instructor, the mentor and the team mates to help him face the difficulties of the professional world respecting a practice-based curriculum containing a balanced theoretical and practical knowledge.

In the faculty side, the learning factory is the place where the student meets the marketing and business mentors to know and understand the business side of his work. The student meets the appropriate mentors to know about the technical side of his tasks and so on. The mobilization of the teaching staff, makes the student more and more ready in the theoretical and analytical side to face what the factory project demands.

The Learning factory is a whole concept. It is a kind of bridge between the university and the professional world. In fact, the companies installed in it are selecting the students of Esprit, not only to hire them but also to give them the possibility to develop their end of year projects (CapStones) inside a working ecosystem. So the engineering students, during their last year of studies, will on the one hand get closer to the practical aspects of what they have learned in the academic environment and on the other hand, these future engineers will have the possibility to build their own professional network so they guarantee their employability once graduated.

It is also important to mention that the active pedagogy that Esprit adopt in the learning process facilitates a lot the team work in these enterprises and also the communication with different agents dealing with them from conceiving the solution for the company to bringing the product or service to the market.

Here we can talk specifically about the advantage that these companies will win from choosing Esprit students to work for them on their prototypes or/& solutions. The big deal is especially the background already prepared that these students have thanks to the BPL (project Based Learning) method that has been installed in their way of resolving problems and designing solutions.

The learning factory becomes with all these valuable strengths of the future engineers a very suitable environment helping the university pin producing operational engineers ready to integrate the market.

### VII. CONCLUSION

In this paper, we presented the experience of establishing the Esprit learning factory as a space in which the graduated student can get in touch with the professional world while maintaining a relationship with his educational ecosystem: the idea, the context and the desired impact.

The desired outcomes of the Tunisian model of the learning factory is mainly to continue being the distinction as an experience and to help providing new opportunities to students nationally and internationally. This distinction may present a model to shape a new economic model in Tunisia, a country recently out from a political transition and therefor, in need of a new type of resources to overcome the transition phase.





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# Summary

### INNOVATION APPROACHES TO DEVELOPMENT OF EDUCATIONAL PROGRAMMES IN THE FIELD OF ENGINEERING

S.I. Koryagin, K.L. Polupan
Immanuel Kant Baltic Federal University

The article is devoted to the main conditions of effective development and design of educational programmes in the field of engineering.

### CONTEMPORARY DISCUSSIONS ON THE CONCEPT OF ELITE ENGINEERING EDUCATION

N.I. Sidnyaev
Bauman Moscow Higher Technical School

Article is devoted to modernization of domestic system of engineering education. According to the innovative development in higher technical education there exist contradictory problems which have been studied. The role of technical universities in preparation of professional elite – scientifically-engineering and state-administrative is considered. Analysis of transformation processes in a domestic education system is presented. Considerable attention is paid to the methods of shaping a modern engineering outlook.

### MODEL OF STUDENTS' PRACTICAL TRAINING PROCESSES IN INSTITUTIONS OF HIGHER PROFESSIONAL EDUCATION

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

The article deals with the model of students' practical training processes, its unit-by-unit description of processes and relationship between them. It forms the basis for subsequent development of a monitoring model.

### MULTIMEDIA LECTURES ON DISCIPLINE "MACHINES PARTS"

M.M. Matlin, I.M. Shandybina, M.V. Topilin, A.N. Goncharenko
Volgograd State Technical University

The method of development and implementation of the multimedia lecture course on discipline "Machine Parts" into the learning process is considered in the article.

### SCIENTIFIC KNOWLEDGE CONCEPT:- CASE STUDY TECHNOLOGY AND ITS PRACTICAL-ORIENTED APPLICATION

M.N. Prosekova
Tyumen State Oil and Gas University

Shaping the competences of a Master-student within the framework of Federal Education Code new generation of Higher Professional Education is implemented through an innovative methodology, i.e. case study (portfolio). This methodology is coupled with such aspects as self-control, cooperativeness and, especially, teamwork. This article is a continuation of previously published papers [3, 4, 5].

### COMPETENCY-BASED APPROACH TO DEVELOPING EDUCATIONAL STANDARD FOR MASTER'SPROGRAM "STANDARDIZATIN AND METROLOGY" AT NORTHERN (ARCTIC) FEDERAL UNIVERSITY N.A. M.V. LOMONOSOV (NArFU)

T.M. Vladimirova, S.I. Tretyakov
Northern (Arctic) Federal University named by M.V. Lomonosov (NArFU)

The article presents the experience in developing educational standard for master's programs in standardization, metrology, and certification. Being developed in line with international practice, the standard extends the scope of professional activities, supplements cultural and professional competences with regard to ecological, economic and ethnic peculiarities of the Russian Arctic zone.

### CURRICULUM DESIGN IN ENGINEERING EDUCATION AND THE ROLE OF PARTNERSHIPS

I. Shimi
Private Engineering School of Technology, Tunisia

Engineering schools have to be aware of three important levels of profile analyzing to guarantee the employability of their graduates: The local market needs in skills, the companies needs in human resources technically, the international openness and importance of partnerships and patronage activities. At Esprit, these three points are considered as key-metrics to design the curriculum in engineering education.

### SHAPING THE PROFESSIONAL COMPETENCES OF UNDERGRADUATESIN ENGINEERING UNIVERSITIES, ILLUSTRATED BY THE INVESTIGATION OF GAS-TURBINE SURFACE AND BLADE VIA ITS AXONOMETRIC DRAFTING

G.A. Pugin, A.B. Mineev
Bauman Moscow State Technical University named after N.E. Bauman

The article describes a course example "Research-Graphic Practicum" oriented at reinforcing previous knowledge and skills in "Engineering Graphics" and further development of professional competences of undergraduates based on the illustrated investigation of the gas-turbine blade. The authors formulated assignments in designing a theoretical model and executed an axonometric draft of the gas-turbine vane.

### METHODOLOGY OF ENGINEERING AND TECHNICAL ACTIVITY ANALYSES FOR DEVELOPMENT OF ACADEMIC CONTENT STANDARDS

G.V. Bukalova
State University – Education-Science-Production Complex

The author addresses the issue of methodology used within the institution to modify the learning outcomes of technical education. The paper represents the methodology for manufacturing process analysis conducted to develop academic content standards for engineering education of automotive profile. The content of structural elements in the analysis of manufacturing process has been substantiated. The methodology for representing production activity parameters in the form of education standards (competences) has been suggested.

### CREATIVITY COMPONENTS IN ENGINEERING EDUCATION

V.A. Mikhailov, A.L. Mikhailov, V.P. Zheltov
Chuvash State University

The article describes the conflicts in the development of engineering education, their algorithm definitions which would be eligible for engineers, researchers, instructors, and students. This, in its turn, is the result of long-term experience in the development and application of about 20 algorithms based on TIPS (Theory of Inventive Problem Solving).

### PECULIARITIES IN SHAPING STAFF PROFESSIONAL SKILLS IN FISHERY INDUSTRY ("PRODUCTION MACHINES AND FACILITIES" EDUCATION PROGRAM)

I.N. Kim
Far Eastern State Technical Fishery University

In leading countries, fishery industry is characterized by high scientific and innovation potential, which makes it one of the leaders at international consumer market. The Russian fishery industry is significantly lagging behind not only other countries in terms of hydrobionts' processing technology, but also Russian pharmaceutical companies and biotech firms.
One of the reasons why Russian fishery industry is lagging behind is low professional level of engineering staff involved in this production. To remedy the situation, it is required to revise engineering training transferring it from qualification-oriented approach to competence-based one, with a graduate acquiring not only professional competences but also skills in innovative ventures.

### ON THE KEY PROBLEM OF ENGINEERING EDUCATION IN MACHINE-TOOL INDUSTRY

K.A. Kapitonova
Rybinsk State Aviation Technological University

The article considers the necessity and opportunity to develop a system mechanism model as an academic process reorganization basis for engineer training in the machine-tool industry.

### THE IMPERATIVE OF ENGINEERING STAFF'S INTELLECTUALIZATION AND COMMON CULTURE ENHANCEMENT

V.V. Likholetov
South Ural State University (National Research University)

The causes for stifling innovation in the country, reduction of the engineers' overall culture and quality of their training have been analyzed. The ways of the future engineer's personality development on the basis of domestic experience and modern TIPS tools are considered.

### ENVIRONMENTAL TRAINING AND EDUCATION

L.B. Khoroshavin
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T.A. Badyina
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Article highlights issues of environmental training in secondary and higher education. Authors suggest universal formula of progressive education, which is targeted at unity and progressive development of Russia by means of environmental training. Current article is of conceptual kind and comprises different areas of environment.

### LEARNING FACTORIES: THE WAY TO CREATE WORLD CLASS GRADUATES THROUGH ENGINEERING EDUCATION

Z.C. Chagra, I. Shimi
The Private High School of Engineering and Technologies, Tunisia

The learning factory can be defined as a type of university – factory (or professional institution or company) that aims to produce better generations of students and make them more ready to market. This paper describes a model of learning factory made at Esprit School of Engineering, Tunis, Tunisia. This paper shows also the specifications of this experience as it is held at in an institution already facing major changes in its curriculum due to following active learning educational approach.

# Public-Professional Accreditation of Curricula (Results)

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

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

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

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

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

Based on the results (21.12.2014) 201 EUR-ACE® labels were awarded to 282 accredited education programs from 47 Russian universities; while in Kazakhstan, 34 education programs from 7 universities were awarded EUR-ACE® Label due to international AEER accreditation.

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





List of Accredited Programs, Russian Federation (as of 01.07.2015)

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Altai State Technical University named after I.I. Polzunov** | | | | |
| 1. | 100400 | INT | Electrical Supply | AEER | 1997-2002 |
| 2. | 120100 | INT | Mechanical Engineering Technology | AEER | 1997-2002 |
| 3. | 120500 | INT | Welding Equipment and Technology | AEER | 1997-2002 |
| 4. | 150900 | FCD | Technology, Equipment and Automation of Mechanical Engineering Productions | AEER | 2003-2008 |
| | **Belgorod State National Research University** | | | | |
| 1. | 210400 | FCD | Telecommunications | AEER EUR-ACE® | 2012-2017 |
| 2. | 210406 | INT | Communication Networks and Switching Systems | AEER EUR-ACE® WA | 2012-2017 |
| 3. | 210602 | INT | Nanomaterials | AEER EUR-ACE® WA | 2012-2017 |
| 4. | 120700 | FCD | Land Management and Cadastre | AEER EUR-ACE® | 2014-2019 |
| 5. | 120700 | SCD | Cadastre and Land Monitoring | AEER EUR-ACE® | 2014-2019 |
| 6. | 130101 | INT | Exploration and Prospecting of Underground Waters and Engineering Geological Survey | AEER EUR-ACE® WA | 2014-2019 |
| 7. | 210700 | FCD | Communication Networks and Commutation Systems | AEER EUR-ACE® | 2014-2019 |
| 8. | 150100 | SCD | Materials Science and Technology | AEER EUR-ACE® | 2015-2020 |
| | **Dagestan State University** | | | | |
| 1. | 210104 | INT | Microelectronics and Solid State Electronics | AEER EUR-ACE® WA | 2013-2018 |
| 2. | 280201 | INT | Environmental Protection and Rational Use of National Resources | AEER EUR-ACE® WA | 2013-2018 |
| | **Higher School of Economics National Research University** | | | | |
| 1. | 11.04.04 | SCD | Electronic Engineering | AEER EUR-ACE® | 2015-2020 |
| | **Ivanovo State Power University** | | | | |
| 1. | 140404 | INT | Nuclear Power Plants and Installations | AEER EUR-ACE® WA | 2009-2014 |
| 2. | 210106 | INT | Industrial Electronics | AEER EUR-ACE® WA | 2009-2014 |
| | **National Research Irkutsk State Technical University** | | | | |
| 1. | 130100 | INT | Aircraft and Helicopter Construction | AEER | 2004-2009 |
| 2. | 250400 | INT | Chemical Engineering of Natural Power Supplies and Carbon-base Materials | AEER | 2004-2009 |
| 3. | 140400 | SCD | Optimization of Developing Power-supply Systems | AEER EUR-ACE® | 2014-2019 |
| 4. | 140400 | SCD | Energy Efficiency, Energy Audit and Energy Department Management | AEER EUR-ACE® | 2014-2019 |
| 5. | 190700 | SCD | Logistic Management and Traffic Control | AEER EUR-ACE® | 2014-2019 |
| 6. | 280700 | SCD | Ecological Safety | AEER EUR-ACE® | 2014-2019 |
| 7. | 280700 | SCD | Waste Management | AEER EUR-ACE® | 2014-2019 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Kazan National Research Technical University named after A.N. Tupolev** | | | | |
| 1. | 150600 | FCD | Science and Technology of New Materials | AEER EUR-ACE® | 2011-2016 |
| 2. | 160100 | FCD | Aircraft Construction and Rocket Production | AEER EUR-ACE® | 2011-2016 |
| 3. | 230100 | FCD | Computer Science | AEER EUR-ACE® | 2011-2016 |
| | **Kazan National Research Technological University** | | | | |
| 1. | 240100 | FCD | Chemical Technology and Biotechnology | AEER | 2004-2009 |
| 2. | 240100 | SCD | Chemical Engineering for Innovative Entrepreneurship | AEER EUR-ACE® | 2013-2018 |
| | **Kemerovo Institute of Food Science and Technology** | | | | |
| 1. | 240700 | FCD | Food Biotechnology | AEER EUR-ACE® | 2013-2018 |
| | **Krasnoyarsk State Technical University** | | | | |
| 1. | 200700 | INT | Radio Engineering | AEER | 1997-2002 |
| 2. | 220100 | INT | Computers, Systems and Networks | AEER | 1997-2002 |
| 3. | 210302 | INT | Radio Engineering | AEER | 2003-2008 |
| | **Komsomolsk-on-Amur State Technical University** | | | | |
| 1. | 140600 | FCD | Electrical Engineering, Electromechanics and Electrical Technology | AEER | 2005-2010 |
| 2. | 140601 | INT | Electromechanics | AEER | 2005-2010 |
| 3. | 140604 | INT | Electrical Drives and Automated Industrial Sets and Engineering Systems | AEER | 2005-2010 |
| | **Kuban State Technological University** | | | | |
| 1. | 260100 | FCD | Technology of Fermentation Manufacture and Winemaking | AEER EUR-ACE® | 2014-2019 |
| 2. | 260100 | FCD | Technology of Bread Products | AEER EUR-ACE® | 2014-2019 |
| 3. | 260100 | FCD | Technology of Fats, Essential Oils, Perfume and Cosmetic Products | AEER EUR-ACE® | 2014-2019 |
| | **«MATI» – Russian State Technological University** | | | | |
| 1. | 190300 | INT | Aircraft instruments, Measuring and Computing complexes | AEER | 1996-2001 |
| 2. | 110400 | INT | Foundry of Ferrous and Non-ferrous Metals | AEER | 1996-2001 |
| 3. | 110500 | INT | Metal Science and Thermal Treatment of Metals | AEER | 1996-2001 |
| 4. | 110700 | INT | Welding Metallurgy | AEER | 1996-2001 |
| | **Moscow State Mining University** | | | | |
| 1. | 090400 | INT | Mine and Underground Construction | AEER | 1996-2001 |
| 2. | 090500 | INT | Open-pit Mining | AEER | 1996-2001 |
| 3. | 130408 | INT | Mine and Underground Construction | AEER EUR-ACE® WA | 2010-2015 |
| | **Moscow State Technological University "Stankin"** | | | | |
| 1. | 120100 | INT | Mechanical Engineering Technology | AEER | 1993-1998 |
| 2. | 120200 | INT | Metal-cutting Machines and Tools | AEER | 1993-1998 |
| 3. | 120400 | INT | Machines and Metal Forming Technology | AEER | 1993-1998 |
| 4. | 210200 | INT | Automation of Technological Processes and Manufacturing | AEER | 1993-1998 |
| 5. | 210300 | INT | Robots and Robotic Systems | AEER | 1993-1998 |
| 6. | 220300 | INT | Automated Production Systems | AEER | 1993-1998 |
| | **Moscow State University of Applied Biotechnology** | | | | |
| 1. | 070200 | INT | Low Temperature Physics and Technology | AEER | 1996-2001 |
| 2. | 170600 | INT | Food Production Machines and Devices | AEER | 1996-2001 |
| 3. | 210200 | INT | Automation of Technological Processes and Manufacturing | AEER | 1996-2001 |
| 4. | 250600 | INT | Plastic and Elastoplastic Processing Technology | AEER | 1996-2001 |
| 5. | 270900 | INT | Meat and Meat Products Technology | AEER | 1996-2001 |
| 6. | 271100 | INT | Milk and Dairy Products Technology | AEER | 1996-2001 |





| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Moscow State Technical University of Radio Engineering, Electronics and Automation** | | | | |
| 1. | 210302 | INT | Radio Engineering | AEER | 2004 -2009 |
| 2. | 220402 | INT | Robots and Robotic Systems | AEER | 2005-2010 |
| 3. | 200203 | INT | Optoelectronic Devices and Systems | AEER | 2005-2010 |
| 4. | 220401 | INT | Mechatronics | AEER | 2005-2010 |
| 5. | 210104 | INT | Microelectronics and Solid State Electronics | AEER | 2005-2010 |
| 6. | 230105 | INT | Computer Technology and Automated Systems Software | AEER | 2005-2010 |
| 7. | 230201 | INT | Information Systems and Technologies | AEER | 2005-2010 |
| 8. | 230101 | INT | Computers, Systems and Networks | AEER EUR-ACE® WA | 2008-2013 |
| 9. | 210104 | INT | Microelectronics and Solid State Electronics | AEER EUR-ACE® WA | 2010-2015 |
| 10. | 200200 | FCD | Optical Engineering | AEER EUR-ACE® | 2010-2015 |
| 11. | 210300 | FCD | Radio Engineering | AEER EUR-ACE® | 2010-2015 |
| 12. | 211000 | SCD | Quality Assurance and Certification of Electronic Equipment | AEER EUR-ACE® | 2013-2018 |
| 13. | 210100 | SCD | Measurement and Information Technologies and Systems | AEER EUR-ACE® | 2013-2018 |
| | **National Research University of Electronic Technology (MIET)** | | | | |
| 1. | 210100 | FCD | Electronics and Microelectronics | AEER | 2003-2008 |
| 2. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| | **National Research University (MPEI)** | | | | |
| 1. | 140600 | FCD | Electrical Engineering, Electromechanics and Electrical Technology | AEER | 2005-2010 |
| 2. | 140602 | INT | Electrical and Electronic Machines | AEER EUR-ACE® | 2007-2012 |
| 3. | 140604 | INT | Electrical Drives and Automated Industrial Sets and Engineering Systems | AEER EUR-ACE® WA | 2007-2012 |
| 4. | 140609 | INT | Electrical Equipment for Aircraft | AEER EUR-ACE® WA | 2007-2012 |
| 5. | 140611 | INT | Insulators, Cables and Capacitors | AEER EUR-ACE® WA | 2007-2012 |
| 6. | 140403 | INT | Technical Physics of Thermonuclear Reactors and Plasma Installations | AEER EUR-ACE® WA | 2010-2015 |
| | **National Research Tomsk Polytechnic University** | | | | |
| 1. | 071600 | INT | High Voltage Engineering and Physics | AEER | 1996-2001 |
| 2. | 080200 | INT | Geology and Prospecting of Mineral Resources | AEER | 1996-2001 |
| 3. | 180100 | INT | Electromechanics | AEER | 1996-2001 |
| 4. | 200400 | INT | Industrial Electronics | AEER | 1996-2001 |
| 5. | 210400 | INT | Applied Mathematics | AEER | 1996-2001 |
| 6. | 250900 | INT | Chemical Engineering of Modern Energetic Materials | AEER | 1999-2004 |
| 7. | 250800 | INT | Chemical Engineering of Refractory Non-Metal and Silicate Materials | AEER | 2000-2005 |
| 8. | 070500 | INT | Nuclear Reactors and Power Plants | AEER | 2000-2005 |
| 9. | 220100 | INT | Computer Science | AEER | 2000-2005 |
| 10. | 100500 | INT | Thermal Power Plants | AEER | 2000-2005 |
| 11. | 101300 | INT | Boiler and Reactor Engineering | AEER | 2000-2005 |
| 12. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| 13. | 140600 | FCD | Electrical Engineering, Electromechanics and Electrical Technology | AEER | 2003-2008 |
| 14. | 140601 | INT | Electromechanics | AEER | 2004-2009 |
| 15. | 140604 | INT | Electrical Drives and Automated Industrial Sets and Engineering Systems | AEER | 2004-2009 |
| 16. | 230101 | INT | Computers, Systems and Networks | AEER | 2004-2009 |
| 17. | 020804 | INT | Geoecology | AEER | 2004-2009 |
| 18. | 130100 | FCD | Geology and Prospecting of Mineral Resources | AEER | 2005-2010 |

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





| | Program Code | Qualifi-cation | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 50. | 240100 | SCD | Chemical Engineering of Refractory Non-Metal and Silicate Materials | AEER EUR-ACE® | 2012-2017 |
| 51. | 150100 | SCD | Science and Technology of Nanomaterials and Coatings | AEER EUR-ACE® | 2012-2017 |
| 52. | 200400 | FCD | Opto-Electronic Equipment and Systems | AEER EUR-ACE® | 2012-2017 |
| 53. | 022000 | FCD | Geoecology | AEER EUR-ACE® | 2012-2017 |
| 54. | 201000 | FCD | Biotechnical and Medical Devices and Systems | AEER EUR-ACE® | 2012-2017 |
| 55. | 140400 | FCD | Electrical Drives and Automation | AEER EUR-ACE® | 2014-2019 |
| 56. | 140400 | FCD | Protection Relay and Automation of Power Grids | AEER EUR-ACE® | 2014-2019 |
| 57. | 221400 | FCD | Quality Management in Manufacturing and Technological Systems | AEER EUR-ACE® | 2014-2019 |
| 58. | 150100 | FCD | Nanostructured Materials | AEER EUR-ACE® | 2014-2019 |
| 59. | 150100 | FCD | Materials Science and Technologies in Mechanical Engineering | AEER EUR-ACE® | 2014-2019 |
| 60. | 150100 | SCD | Nanostructured Materials Tool Production | AEER EUR-ACE® | 2014-2019 |
| 61. | 150100 | SCD | Computer Simulation of Material Production, Processing and Treatment | AEER EUR-ACE® | 2014-2019 |
| 62. | 130101 | INT | Petroleum Geology | AEER EUR-ACE® WA | 2014-2019 |
| 63. | 12.04.02 | SCD | Lighting Technology and Light Sources | AEER EUR-ACE® | 2014-2019 |
| 64. | 12.04.02 | SCD | Photonic Technologies and Materials | AEER EUR-ACE® | 2014-2019 |
| 65. | 15.04.01 | SCD | High-technology Physics in Mechanical Engineering | AEER EUR-ACE® | 2014-2019 |
| 66. | 19.03.01 | FCD | Biotechnology | AEER EUR-ACE® | 2014-2019 |
| 67. | 12.04.04 | SCD | Medical and Biological Devices, Systems and Complexes | AEER EUR-ACE® | 2014-2019 |
| 68. | 15.03.01 | FCD | Automation of Manufacturing Processes and Production in Mechanical Engineering | AEER EUR-ACE® | 2014-2019 |
| 69. | 21.05.03 | INT | Geology and Exploration of Minerals | AEER EUR-ACE® WA | 2014-2019 |
| 70. | 21.05.03 | INT | Geophysical Methods of Well Logging | AEER EUR-ACE® WA | 2014-2019 |
| 71. | 11.04.04 | SCD | Electronics and Nanoelectronics | AEER EUR-ACE® | 2015-2020 |
| 72. | 27.04.01 | SCD | Standardization and Metrology | AEER EUR-ACE® | 2015-2020 |
| | **National Research University «Lobachevsky State University of Nizhni Novgorod»** | | | | |
| 1. | 010300 | FCD | Software Engineering | AEER EUR-ACE® | 2014-2019 |
| 2. | 010300 | FCD | Fundamental Computer Science and Information Technologies (in English) | AEER EUR-ACE® | 2014-2019 |
| 3. | 010300 | SCD | Software Engineering | AEER EUR-ACE® | 2014-2019 |
| | **National University of Science and Technology «MISIS»** | | | | |
| 1. | 150101 | INT | Metallurgy of Ferrous Metals | AEER | 2004-2009 |
| 2. | 150105 | INT | Metal Science and Thermal Treatment of Metals | AEER | 2004-2009 |
| 3. | 150601 | INT | Science and Technology of New Materials | AEER | 2004-2009 |
| 4. | 150400 | FCD | Metallurgy of Ferrous Metals | AEER EUR-ACE® | 2011-2016 |
| 5. | 150400 | FCD | Physical Metallurgy of Non-Ferrous, Rare-Earth and Precious Metals | AEER EUR-ACE® | 2011-2016 |
| 6. | 150400 | FCD | Functional Materials and Coatings | AEER EUR-ACE® | 2011-2016 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 7. | 150400 | FCD | Metal Forming | AEER EUR-ACE® | 2011-2016 |
| 8. | 011200 | FCD | Physics of Condensed Matter | AEER EUR-ACE® | 2012-2017 |
| 9. | 150100 | FCD | Materials Science and Engineering of Functional Materials for Nanoelectronics | AEER EUR-ACE® | 2012-2017 |
| 10. | 150400 | FCD | Metallurgy of Non-ferrous, Rare and Precious Metals | AEER EUR-ACE® | 2012-2017 |
| 11. | 151000 | FCD | Metallurgical Machines and Equipment | AEER EUR-ACE® | 2012-2017 |
| 12. | 210100 | FCD | Semiconductor Devices for Micro- and Nanoelectronics | AEER EUR-ACE® | 2012-2017 |
| 13. | 210100 | FCD | Materials and Technologies of Magnetoelectronics | AEER EUR-ACE® | 2012-2017 |
| 14. | 210100 | FCD | Micro- and Nanotechnology Processes | AEER EUR-ACE® | 2012-2017 |
| 15. | 220700 | FCD | Automated Systems in Manufacturing | AEER EUR-ACE® | 2012-2017 |
| 16. | 230100 | FCD | Automated Systems | AEER EUR-ACE® | 2012-2017 |
| 17. | 150400 | SCD | Metallurgy of Non-Ferrous and Precious Metals | AEER EUR-ACE® | 2014-2019 |
| 18. | 011200 | SCD | Physics of Condensed Matter | AEER EUR-ACE® | 2014-2019 |
| 19. | 011200 | SCD | Physics of Nanosystems | AEER EUR-ACE® | 2014-2019 |
| 20. | 210100 | SCD | Materials and Technologies of Magnetoelectronics | AEER EUR-ACE® | 2014-2019 |
| 21. | 210100 | SCD | Micro- and Nanotechnology Processes | AEER EUR-ACE® | 2014-2019 |
| | **North-Caucasus Federal University** | | | | |
| 1. | 140400 | FCD | Electrical Power Systems and Networks | AEER EUR-ACE® | 2015-2020 |
| 2. | 240100 | FCD | Process Chemistry of Natural Energy Carriers and Carbon Materials | AEER EUR-ACE® | 2015-2020 |
| 3. | 090900 | FCD | Organization and Technology of Information Security | AEER EUR-ACE® | 2015-2020 |
| 4. | 090303 | INT | Information Security of Automated Systems | AEER EUR-ACE® | 2015-2020 |
| 5. | 131000 | SCD | Oil Field Reservoir Management | AEER EUR-ACE® | 2015-2020 |
| 6. | 140400 | SCD | Monitoring and Control of Electrical Networks Based on Intelligent Information-Measuring Systems and Technologies | AEER EUR-ACE® | 2015-2020 |
| | **Nosov Magnitogorsk State Technical University** | | | | |
| 1. | 150400 | FCD | Forming of Metals and Alloys (Rolling) | AEER EUR-ACE® | 2014-2019 |
| 2. | 150400 | SCD | Rolling Production Technology | AEER EUR-ACE® | 2014-2019 |
| 3. | 27.04.01 | SCD | Testing and certification | AEER EUR-ACE® | 2015-2020 |
| 4. | 22.04.02 | SCD | Hardware Production Technology | AEER EUR-ACE® | 2015-2020 |
| 5. | 11.04.04 | SCD | Industrial Electronics and Automation of Electrical Systems | AEER EUR-ACE® | 2015-2020 |
| 6. | 03.04.02 | SCD | Solid State Physics | AEER EUR-ACE® | 2015-2020 |
| | **Novosibirsk State Technical University** | | | | |
| 1. | 150501 | INT | Materials Science in Mechanical Engineering | AEER EUR-ACE® WA | 2012-2017 |
| | **Ogarev Mordovia State University** | | | | |
| 1. | 151900 | FCD | Mechanical Engineering Technology | AEER EUR-ACE® | 2014-2019 |
| 2. | 210100 | FCD | Industrial Electronics | AEER EUR-ACE® | 2014-2019 |





| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 3. | 11.04.04 | SCD | Electronics and Nanoelectronics | AEER EUR-ACE® | 2015-2020 |
| | **Penza State University** | | | | |
| 1. | 11.04.04 | SCD | Electronics and Nanoelectronics | AEER EUR-ACE® | 2015-2020 |
| 2. | 27.04.01 | SCD | Standardization and Metrology | AEER EUR-ACE® | 2015-2020 |
| | **Peoples' Friendship University of Russia** | | | | |
| 1. | 270100 | SCD | Structural Theory and Engineering | AEER EUR-ACE® | 2013-2018 |
| 2. | 270100 | SCD | River and Underground Hydraulic Engineering Works | AEER EUR-ACE® | 2013-2018 |
| 3. | 270100 | SCD | Theory and Practice of Organizational, Technical and Economic Decisions in Building and Construction | AEER EUR-ACE® | 2013-2018 |
| 4. | 141100 | SCD | Internal Combustion Engines | AEER EUR-ACE® | 2013-2018 |
| 5. | 141100 | SCD | Steam- and Gas Turbine Plants and Engines | AEER EUR-ACE® | 2013-2018 |
| | **Perm National Research Polytechnic University** | | | | |
| 1. | 150700 | SCD | Beam Technologies in Welding | AEER EUR-ACE® | 2014-2019 |
| 2. | 270800 | SCD | Underground and Urban Construction | AEER EUR-ACE® | 2014-2019 |
| | **Petrozavodsk State University** | | | | |
| | 210100 | SCD | Electronics and Nanoelectronics | AEER EUR-ACE® | 2015-2020 |
| | **Samara State Aerospace University (National Research University)** | | | | |
| 1. | 160301 | INT | Aircraft Engines and Power Plants | AEER EUR-ACE® WA | 2008-2013 |
| 2. | 160802 | INT | Spasecraft and Rocket Boosters | AEER EUR-ACE® WA | 2008-2013 |
| 3. | 24.05.01 | INT | Design, Production and Maintenance of Rockets and Space Complexes | AEER EUR-ACE® WA | 2015-2020 |
| 4. | 24.05.07 | INT | Airplane and Helicopter Designing | AEER EUR-ACE® WA | 2015-2020 |
| 5. | 12.04.04 | SCD | Biotechnical Systems and Technologies | AEER EUR-ACE® | 2015-2020 |
| 6. | 01.04.02 | SCD | Supercomputing, Information Technologies and Geoinformatics | AEER EUR-ACE® | 2015-2020 |
| | **Saint Petersburg Electrotechnical University "LETI"** | | | | |
| 1. | 220200 | FCD | Automation and Control | AEER | 2003-2008 |
| 2. | 210100 | FCD | Electronics and Microelectronics | AEER | 2003-2008 |
| 3. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| 4. | 200300 | FCD | Biomedical Engineering | AEER | 2003-2008 |
| 5. | 210400 | FCD | Radio Electronic Systems | AEER EUR-ACE® | 2014-2019 |
| 6. | 210400 | FCD | Radiotechnical Devices for Signal Transmission, Reception and Processing | AEER EUR-ACE® | 2014-2019 |
| 7. | 210400 | FCD | Audiovision Equipment | AEER EUR-ACE® | 2014-2019 |
| 8. | 210100 | FCD | Electronic Devices | AEER EUR-ACE® | 2014-2019 |
| 9. | 200100 | FCD | Information and Measurement Technique and Technology | AEER EUR-ACE® | 2014-2019 |
| 10. | 200100 | FCD | Laser Measurement and Navigation Systems | AEER EUR-ACE® | 2014-2019 |
| 11. | 200100 | FCD | Devices and Methods of Monitoring of Quality and Diagnostics | AEER EUR-ACE® | 2014-2019 |
| 12. | 231000 | SCD | Development of Distributed Software Systems | AEER EUR-ACE® | 2014-2019 |

| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 13. | 010400 | SCD | Mathematical Provisions and Software of Computers | AEER EUR-ACE® | 2014-2019 |
| 14. | 220451 | SCD | Automation and Control of Industrial Complexes and Mobile Objects | AEER EUR-ACE® | 2014-2019 |
| 15. | 220452 | SCD | Automated Control Systems for Sea Vehicles | AEER EUR-ACE® | 2014-2019 |
| 16. | 220453 | SCD | Shipborne Information and Control Systems | AEER EUR-ACE® | 2014-2019 |
| 17. | 140452 | SCD | Automated Electromechanical Complexes and Systems | AEER EUR-ACE® | 2014-2019 |
| 18. | 230161 | SCD | Microsystem Computer Technologies: Systems on Chip | AEER EUR-ACE® | 2014-2019 |
| 19. | 230162 | SCD | Distributed Intelligent Systems and Technology | AEER EUR-ACE® | 2014-2019 |
| 20. | 230151 | SCD | Computer Technologies in Engineering | AEER EUR-ACE® | 2014-2019 |
| 21. | 201051 | SCD | Biotechnical Systems and Technologies of Rehabilitation and Prosthetics | AEER EUR-ACE® | 2014-2019 |
| 22. | 201053 | SCD | Information Systems and Technologies in Patient Care Institutions | AEER EUR-ACE® | 2014-2019 |
| 23. | 210153 | SCD | Electronic Devices and Equipment | AEER EUR-ACE® | 2014-2019 |
| 24. | 210176 | SCD | Physical Electronics | AEER EUR-ACE® | 2014-2019 |
| 25. | 210152 | SCD | Microwave and Telecommunication Electronics | AEER EUR-ACE® | 2014-2019 |
| 26. | 211006 | FCD | Information Technologies for Radio Electronic Engineering | AEER EUR-ACE® | 2014-2019 |
| 27. | 211008 | FCD | Information Technologies in Microwave Electronic Engineering | AEER EUR-ACE® | 2014-2019 |
| 28. | 11.04.04 | SCD | Nanoelectronics and photonics | AEER EUR-ACE® | 2015-2020 |
| | **Saint Petersburg National Research University of Information Technologies, Mechanics and Optics** | | | | |
| 1. | 27.04.03 | SCD | Intelligent Control Systems of Technological Processes | AEER EUR-ACE® | 2014-2019 |
| 2. | 09.04.01 | SCD | Embedded Computer Systems Design | AEER EUR-ACE® | 2014-2019 |
| 3. | 09.04.02 | SCD | Automation and Control in Educational Systems | AEER EUR-ACE® | 2014-2019 |
| 4. | 09.04.03 | SCD | Overall Automation of Enterprise | AEER EUR-ACE® | 2014-2019 |
| 5. | 24.04.01 | SCD | Quality Control of Products of Space Rocket Complexes | AEER EUR-ACE® | 2014-2019 |
| 6. | 12.04.02 | SCD | Applied Optics | AEER EUR-ACE® | 2014-2019 |
| 7. | 16.04.01 | SCD | Integrated Analyzer Systems and Information Technologies of Fuel and Energy Complex Enterprises | AEER EUR-ACE® | 2014-2019 |
| 8. | 19.04.03 | SCD | Biotechnology of Therapeutic, Special and Prophylactic Nutrition Products | AEER EUR-ACE® | 2014-2019 |
| | **Saint-Petersburg State Polytechnic University** | | | | |
| 1. | 010800 | SCD | Mechanics of Deformable Solid Body | AEER EUR-ACE® | 2014-2019 |
| 2. | 210700 | SCD | Protected Telecommunication Systems | AEER EUR-ACE® | 2014-2019 |
| 3. | 210100 | SCD | Micro- and Nanoelectronics | AEER EUR-ACE® | 2014-2019 |
| 4. | 223200 | SCD | Physics of Low-dimensional Structures | AEER EUR-ACE® | 2014-2019 |
| 5. | 151900 | SCD | Machine-building Technology | AEER EUR-ACE® | 2014-2019 |
| 6. | 140100 | SCD | Technology of Production of Electric Power and Heat | AEER EUR-ACE® | 2014-2019 |
| 7. | 220100 | SCD | System Analysis and Control | AEER EUR-ACE® | 2014-2019 |
| 8. | 270800 | SCD | Engineering Systems of Buildings and Constructions | AEER EUR-ACE® | 2014-2019 |
| 9. | 270800 | SCD | Construction Management of Investment Projects | AEER EUR-ACE® | 2014-2019 |





| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Siberian State Aerospace University** | | | | |
| 1. | 220100 | FCD | System Analysis and Control | AEER EUR-ACE® | 2011-2016 |
| 2. | 230100 | FCD | Computer Science and Computer Facilities | AEER EUR-ACE® | 2011-2016 |
| 3. | 11.04.04 | SCD | Electronic Devices and Facilities | AEER EUR-ACE® | 2015-2020 |
| 4. | 11.04.02 | SCD | Telecommunication Networks and Communication Devices | AEER EUR-ACE® | 2015-2020 |
| 5. | 11.04.02 | SCD | Satellite Communication Systems | AEER EUR-ACE® | 2015-2020 |
| | **Siberian Federal University** | | | | |
| 1. | 210200 | SCD | Microwave Equipment and Antennas | AEER EUR-ACE® | 2010-2015 |
| 2. | 230100 | SCD | High-Performance Computing Systems | AEER EUR-ACE® | 2010-2015 |
| | **Stary Oskol Technological Institute named after A.A. Ugarov (branch of National University of Science and Technology «MISIS»)** | | | | |
| 1. | 150400 | FCD | Metallurgy of Ferrous Metals | AEER EUR-ACE® | 2012-2015 |
| | **Taganrog Institute of Technology of Southern Federal University** | | | | |
| 1. | 210100 | FCD | Electronics and Microelectronics | AEER | 2003-2008 |
| 2. | 230100 | FCD | Computer Science | AEER | 2003-2008 |
| 3. | 230100 | FCD | Computer Science | AEER EUR-ACE® | 2010-2015 |
| 4. | 220200 | FCD | Automation and Control | AEER EUR-ACE® | 2010-2015 |
| 5. | 210100 | FCD | Electronics and Microelectronics | AEER EUR-ACE® | 2012-2017 |
| 6. | 200100 | FCD | Equipment Engineering | AEER EUR-ACE® | 2012-2017 |
| | **Tambov State Technical University** | | | | |
| 1. | 210201 | INT | Design and Technology of Radioelectronic Devices | AEER | 2006-2011 |
| 2. | 140211 | INT | Electrical Supply | AEER | 2006-2011 |
| | **Togliatty State University** | | | | |
| 1. | 140211 | INT | Electrical Supply | AEER EUR-ACE® WA | 2009-2014 |
| 2. | 150202 | INT | Industrial Welding Technology and Equipment | AEER EUR-ACE® WA | 2009-2014 |
| 3. | 151002 | INT | Mechanical Engineering Technology | AEER EUR-ACE® WA | 2009-2014 |
| | **Tomsk State University of Control Systems and Radio Electronics** | | | | |
| 1. | 210100 | FCD | Industrial electronics | AEER EUR-ACE® | 2013-2018 |
| 2. | 222000 | FCD | Innovation Management in Electronic Engineering | AEER EUR-ACE® | 2013-2018 |
| | **Trekhgorny Technological Institute** | | | | |
| 1. | 230101 | INT | Computers, Systems and Networks | AEER | 2004-2007 |
| | **Tyumen State Oil and Gas University** | | | | |
| 1. | 130501 | INT | Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities | AEER | 2006-2011 |
| 2. | 130503 | INT | Development and Exploitation of Oil and Gas Fields | AEER | 2006-2011 |
| 3. | 130504 | INT | Oil and Gas Drilling | AEER | 2006-2011 |
| 4. | 190601 | INT | Automobiles and Transportation Facilities | AEER WA | 2007-2012 |
| 5. | 190603 | INT | Transport and technological machinery and equipment service (oil and gas production) | AEER WA | 2007-2012 |
| 6. | 190701 | INT | Transportation organization and transport management (automobile transport) | AEER WA | 2007-2012 |

| | Program Code | Qualifi-cation | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 7. | 130602 | INT | Oil and Gas Fields Machinery and Equipment | AEER EUR-ACE® WA | 2008-2013 |
| 8. | 150202 | INT | Industrial Welding Technology and Equipment | AEER EUR-ACE® | 2008-2011 |
| 9. | 190205 | INT | Lifting, Transportation Means and Road Machines | AEER EUR-ACE® WA | 2008-2013 |
| 10. | 240401 | INT | Chemical Technology of Organic Substances | AEER EUR-ACE® WA | 2009-2014 |
| 11. | 240403 | INT | Chemical Engineering of Natural Power Supplies and Carbon-base Materials | AEER EUR-ACE® WA | 2009-2014 |
| 12. | 240801 | INT | Machines and Apparatus of Chemical Production | AEER EUR-ACE® WA | 2009-2014 |
| 13. | 280201 | INT | Environmental Control and Rational Use of Natural Resources | AEER EUR-ACE® WA | 2010-2015 |
| 14. | 280102 | INT | Safety of Technological Processes and Productions | AEER EUR-ACE® WA | 2010-2015 |
| 15. | 120302 | INT | Land Cadastre | AEER EUR-ACE® WA | 2010-2015 |
| | **Tyumen State University of Architecture and Civil Engineering** | | | | |
| 1. | 270800 | SCD | Water Supply and Sanitation | AEER EUR-ACE® | 2013-2018 |
| 2. | 270800 | SCD | Industrial and Civil Construction | AEER EUR-ACE® | 2013-2018 |
| 3. | 280700 | SCD | Safety of Technological Processes and Production | AEER EUR-ACE® | 2013-2018 |
| | **Ural State Forest Engineering University** | | | | |
| 1. | 270205 | INT | Automobile Roads and Aerodromes | AEER | 2006-2011 |
| | **Ural Federal University named after the first President of Russia B.N. Yeltsin** | | | | |
| 1. | 240302 | INT | Technology of Electrochemical Productions | AEER EUR-ACE® | 2008-2013 |
| 2. | 210100 | SCD | Electronics and Nanoelectronics | AEER EUR-ACE® | 2015-2020 |
| 3. | 221700 | SCD | Standardization and Metrology | AEER EUR-ACE® | 2015-2020 |
| | **Ufa State Aviation Technical University** | | | | |
| 1. | 280200 | FCD | Environment Protection | AEER | 2005-2010 |
| 2. | 230100 | FCD | Computer Science | AEER | 2005-2010 |
| 3. | 150501 | INT | Material Science in Mechanical Engineering | AEER | 2005-2010 |
| 4. | 280200 | SCD | Environment Protection | AEER EUR-ACE® | 2008-2013 |
| | **Ufa State Petroleum Technological University** | | | | |
| 1. | 130504 | INT | Oil and Gas Drilling | AEER EUR-ACE® WA | 2007-2012 |
| 2. | 130603 | INT | Oil and Gas Processing Equipment | AEER EUR-ACE® WA | 2007-2012 |
| 3. | 150400 | FCD | Processing Machinery and Equipment | AEER EUR-ACE® | 2007-2012 |
| 4. | 240100 | FCD | Chemical Engineering and Biotechnology | AEER EUR-ACE® | 2008-2013 |
| 5. | 240403 | INT | Chemical Engineering of Natural Power Supplies and Carbon-base Materials | AEER EUR-ACE® WA | 2008-2013 |
| 6. | 130602 | INT | Oil and Gas Fields Machinery and Equipment | AEER EUR-ACE® WA | 2008-2013 |





| | Program Code | Qualifi-cation | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 7. | 130501 | INT | Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities | AEER EUR-ACE® WA | 2009-2014 |
| 8. | 551830 | SCD | Equipment Design Theory for Oil and Gas Processing, Petrochemical and Chemical Production | AEER EUR-ACE® | 2010-2015 |
| 9. | 551831 | SCD | Technological Systems and Equipment Reliability | AEER EUR-ACE® | 2010-2015 |
| 10. | 550809 | SCD | Chemical Engineering of Fuel and Gas | AEER EUR-ACE® | 2010-2015 |
| 11. | 270100 | FCD | Building Construction | AEER EUR-ACE® | 2011-2016 |
| 12. | 550109 | SCD | Building Construction | AEER EUR-ACE® | 2011-2016 |
| 13. | 131000 | FCD | Petroleum Engineering | AEER EUR-ACE® | 2013-2018 |
| 14. | 151000 | FCD | Production Machines and Equipment | AEER EUR-ACE® | 2013-2018 |
| 15. | 241000 | FCD | Environmental Protection and Rational Use of National Resources | AEER EUR-ACE® | 2015-2020 |
| 16. | 240100 | FCD | Process Chemistry of Natural Energy Carriers and Carbon Materials | AEER EUR-ACE® | 2015-2020 |
| 17. | 140400 | FCD | Electrical Equipment and Electrical Facilities of Companies, Organizations and Institutions | AEER EUR-ACE® | 2015-2020 |
| | **Vladimir State University named after Alexander and Nikolay Stoletovs** | | | | |
| 1. | 150900 | FCD | Technology, Equipment and Automation of Mechanical Engineering Productions | AEER EUR-ACE® | 2012-2017 |
| 2. | 230100 | FCD | Computer Science | AEER EUR-ACE® | 2012-2017 |

## List of Accredited Programs, Republic of Kazakhstan (as of 01.07.2015)

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





| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| 5. | 050713 | FCD | Transport, Transport Facilities and Technology | AEER EUR-ACE® | 2010-2015 |
| | **Kostanay Engineering and Pedagogical University (Kostanay, Republic of Kazakhstan)** | | | | |
| 1. | 050713 | FCD | Transport, Transport Equipment and Technology | AEER EUR-ACE® | 2011-2016 |
| 2. | 050732 | FCD | Standardization, Metrology and Certification | AEER EUR-ACE® | 2011-2016 |
| | **Semey State University named after Shakarim (Semey, Republic of Kazakhstan)** | | | | |
| 1. | 050727 | FCD | Food Technology | AEER EUR-ACE® | 2010-2015 |
| 2. | 050724 | FCD | Processing Machinery and Equipment | AEER EUR-ACE® | 2010-2015 |
| | | | | | |

## List of Accredited Secondary Professional Education Programs ((as of 01.07.2015)

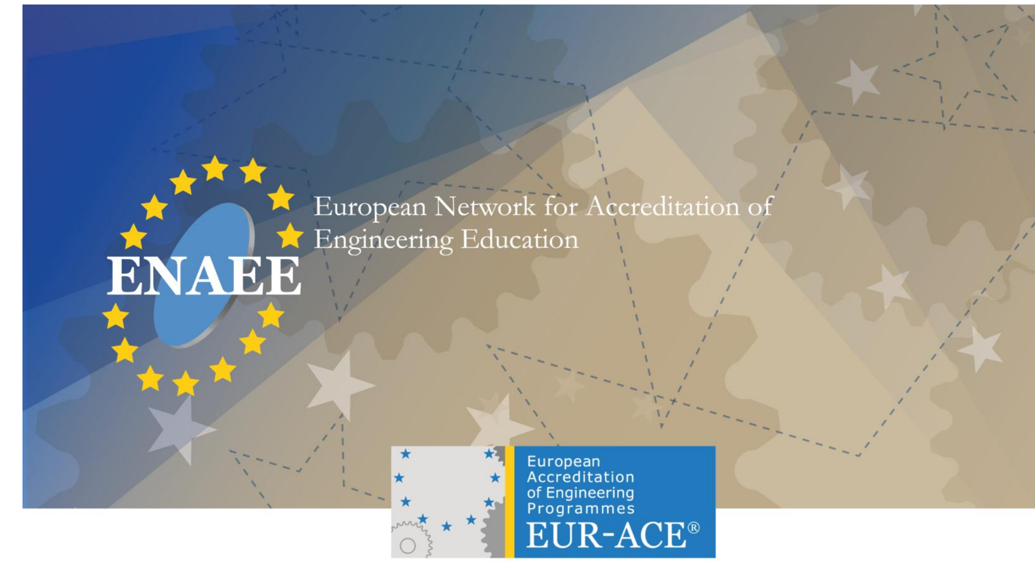
| | Program Code | Qualification | Program Name | Certificate | Accreditation Period |
|---|---|---|---|---|---|
| | **Tomsk Polytechnic College** | | | | |
| 1. | 131003 | T | Oil and Gas Drilling | AEER | 2014-2019 |
| | **Tomsk Industrial College** | | | | |
| 1. | 140448 | T | Technical Operation and Maintenance of Electrical and Electromechanical Equipment | AEER | 2014-2019 |
| | **Tomsk College of Information Technologies** | | | | |
| 1. | 230115 | T | Computer Systems Programming | AEER | 2014-2019 |

# AEER re-authorization to award the «EUR-ACE® Label»

Meeting of the Administrative Council of ENAEE (European Network for Accreditation of Engineering Education) was held in Istanbul on June 23, 2015. During this meeting the Association of Engineering Education of Russia was authorized to award European quality label «EUR-ACE Bachelor Label» to accredited engineering programmes at first cycle level (bachelor) and «EUR-ACE Master Label» to accredited engineering programmes at second cycle level (diploma specialist, master) until **31st of December (http://www.enaee.eu/wp-content/uploads/2012/01/overview-WEB-of-all-authorizations-granted4.pdf)**

Following 13 national agencies are authorised to award the EUR-ACE® label to their accredited programmes:

1. **GERMANY** – ASIIN – Fachakkreditierungsagentur fьr Studiengдnge der Ingenieurwissenschaften, der Informatik, der Naturwissenschaften, und der Mathematik e.V. – www.asiin.de
2. **FRANCE** – CTI – Commission des Titres d'Ingйnieur – www.cti-commission.fr
3. **UK** – Engineering Council – www.engc.org.uk
4. **IRELAND** – Engineers Ireland – www.engineersireland.ie
5. **PORTUGAL** – Ordem dos Engenheiros – www.ordemengenheiros.pt
6. **RUSSIA** – AEER – Association for Engineering Education of Russia – www.aeer.ru
7. **TURKEY** – MьDEK – Association for Evaluation and Accreditation of Engineering Programs – www.mudek.org.tr
8. **ROMANIA** – ARACIS – The Romanian Agency for Quality Assurance in Higher Education – www.aracis.ro
9. **ITALY** – QUACING – Agenzia per la Certificazione di Qualita e l'Accreditamen to EUR-ACE dei Corsi di Studio in Ingegneria – www.quacing.it
10. **POLAND** – KAUT – Komisja Akredytacyjna Uczelni Technicznych – www.kaut.agh.edu.pl
11. **SWITZERLAND** – AAQ - Schweizerische Agentur fьr Akkreditierung und Qualitдtssicherung – www.aaq.ch
12. **SPAIN** – ANECA – National Agency for Quality Assessment and Accreditation of Spain – www.aneca.es (in conjunction with IIE – Instituto de la Ingenierнa de Espaca – www.iies.es)
13. **FINLAND** – FINEEC – Korkeakoulujen arviointineuvosto KKA – http://karvi.fi/en/




AEER

Association for Engineering Education of Russia

is re-authorized

from 31 June 2015
to 31 December 2019

to award the EUR-ACE® Label to accredited
Bachelor and Master level engineering programmes

Brussels, 23 June 2015

**EUR-ACE label awards: Authorization Period**

Status: 23 June 2015

| Country | Agency | First Cycle | From | Until | | Second Cycle | From | Until |
|---|---|---|---|---|---|---|---|---|
| DE | ASIIN | **X** | Nov 2008 | **31 Dec 2019** | | **X** | Nov 2008 | **31 Dec 2019** |
| FR | CTI | | | | | **X** | Nov 2008 | **31 Dec 2019** |
| IE | EI | **X** | Nov 2008 | **31 Dec 2018** | | **X Honors Bachelor** | Nov 2010 | **31 Dec 2018** |
| | | | | | | **X Master SC** | Sept 2012 | **31 Dec 2018** |
| PT | OE | **X** | Sept 2013 | **31 Dec 2018** | | **X** | Jan 2009 | **31 Dec 2018** |
| RU | AEER | **X** | Nov 2008 | **31 Dec 2019** | | **X** | Nov 2008 | **31 Dec 2019** |
| TR | MÜDEK | **X** | Jan 2009 | **31 Dec 2018** | | | | |
| UK | EngC | **X** | Nov 2008 | **31 Dec 2016** | | **X** | Nov 2008 | **31 Dec 2016** |
| RO | ARACIS | **X** | Sept 2012 | **31 Dec 2017** | | | | |
| IT | QUACING | **X** | Sept 2012 | **31 Dec 2015** | | **X** | Sept 2012 | **31 Dec 2015** |
| PL | KAUT | **X** | Sept 2013 | **31 Dec 2018** | | **X** | Sept 2015 | **31 Dec 2018** |
| ES | ANECA (w/IIE) | **X** | June 2014 | **31 Dec 2018** | | **X** | June 2014 | **31 Dec 2018** |
| FI | FINEEC | **4Y Bachelor** | June 2014 | **31 Dec 2018** | | | | |
| CH | OAQ | **X** | June 2014 | **31 Dec 2018** | | **X** | June 2014 | **31 Dec 2018** |

# ИНЖЕНЕРНОЕ ОБРАЗОВАНИЕ

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