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Dear readers!

The challenges of engineering education currently become more and more acute. The delayed responses to these challenges are blamed on intensive global changes in science and technology. Another reason of the tardy responses to the challenges of the external and internal environment is the rigidity of the education system in general, and engineering training, in particular. It has a negative impact not only on the system of engineering education, but also on national society and economy, engineering capability and homeland security of the country.

The scientific, engineering and educational community is hardly indifferent to these problems. Hundreds of national and international scientific workshops, methodical seminars, and conferences are annually held in Russia. These issues are also discussed in public consultations and parliamentary hearings. The discussions result in numerous recommendations, some of which, if being timely implemented, would contribute to positive changes in the system of engineering training. However, as a rule, the recommendations approved by the professional community are not implemented or implemented far too late.

The AEER experts have analyzed the implementation rate of the recommendations approved at the conferences and hearings. Thus, during the studied period (three years) there were 52 events, including 7 federal scale arrangements, and 45 regional events held in different regions of the RF. They approved a number of recommendations aimed at improving the Russian system of engineering training and creating conditions for successful engineering development. The total number of recommendations was 141, including those that were repeated, and 98 without regard to the repeated ones. Among the latter 5 recommendations were implemented, 40 were being implemented, there was no information about 6 recommendations, and 47 are not implemented, which makes up more than a half of the total number. It should be noted that 30% of the whole number of recommendations related to the strategy of engineering education development and improvement of legal framework for engineering training. More than 70 % of the recommendations concerned internal university issues, for example, engineering training content and techniques, education quality, monitoring, management system, etc.

The latter circumstance proves the fact that a great number of issues related to the engineering education system that meet the global and national challenges depend on university's staff – managerial, scientific and teaching ones. The success or failure of university mission strongly depends on skill level of the university staff involved in scientific, educational and managerial activities. The staff's skill level, as well as their public stance, influences not only the content (core) of engineering training, but also the degree of the process bureaucratization, goal-setting, and choice of means for goal achievement. One of the tasks to be performed by the engineering educational and scientific community is to change a focus from the indicators that have no direct relation to the quality of engineering training on those ones that reflect its real development. In this regard, closer attention should be paid to the system of further professional development for university staff, since their skill level ensures university efficiency in meeting challenges and rapidly changing requirements. Formally, the system performance is stable and efficient. As a rule, a career promotion of any university staff requires a certificate in further training dated no later than 5 years. It should be noted that some of the events mentioned above provided such certificates for the participants. However, these certificates can only confirm that a person has been provided with new and perhaps useful information, but they cannot ensure efficient application of the information for the university's needs. A great rate of non-implemented recommendations may indirectly prove this fact.

Within this context, the system of further training for faculty, scientific and managerial staff of engineering universities may serve as one of the most prospective area for the development of Russian engineering education. Federal and regional education managers should also be involved in the further training programmes. We should also note that the faculty implementing engineering programmes, especially those who deliver design and technological courses, should have specific industrial further training. There is no stimulation in universities for such form of faculty's industrial training as training at leading plants to develop brand new skills required in modern engineering activities. This fact hinders the improvement of engineering training, since the famous rule "You cannot teach what you cannot do" still works.

We consider that there are three basic principles to be followed while developing further professional training for university staff: **focus on innovation, practice and efficiency**.

Each of the principles is implemented via definite actions and ways.

Focus on innovation achieved via understanding and implementation of unique and effective university management methods and educational techniques that ensure internationally recognized standards (in terms of graduates, research insights and engineering).

Practice-oriented focus is implemented via changes in content and implementation of education programmes, and further training programmes with taking into account acute problems of engineering training.

Focus on efficiency implies higher requirements for implementing learning outcomes obtained by graduates during training programmes.

In fact, within specified time, a trainee should demonstrate improved professional activities as a positive result of further training course, which is assisted by an organization that provides the course. The certificate in further training should contain the data about the efficient implementation of learning outcomes. It is also necessary to develop an efficient recording system to register learning outcomes related to specific problem solving and responses to particular challenges. If these three principles and the recording system are implemented, we will succeed in improving Russian engineering education and making it more attractive for both national and international applicants for engineering programmes.

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

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Competency Development and Innovative Trends in Engineering E-Learning

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Abstract

The article examines the main issues related to the innovation implementation into the engineering e-leaning. It presents the examples of using information technologies: micro-knowledge, animations, simulation, and chatbots.

Key words: e-learning, Internet-technology, competency, micro-knowledge, gamification, simulation, chatbot.

1. Introduction

In the middle of the 1990s mass-produced personal computers definitely became a personal tool for information processing. The first digital content was presented by electronical books including manuals, course lectures, and textbooks. It was the first study materials – prototypes of modern e-learning programs. The term itself "e-learning" was introduced in 1997 by Aldo Morri and Jay Cross, pioneers in this field. Along with the economics and management, new dimensions in engineering e-learning have recently emerged.

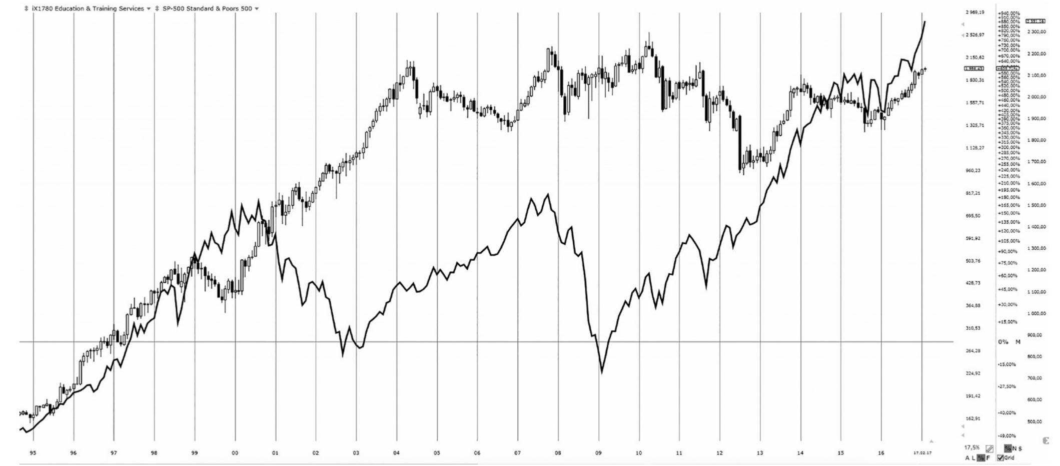
2. Internet technologies in e-learning

Despite the fact that the first computer-based education systems were invented in the 1970s, an explosive growth of using computer in education was seen only three decades later and primarily stipulated by mass introduction of internet technologies and boom of so-called dotcom (dot-com, dot.com). The term "dotcom" is referred to the companies whose core business is entirely internet related. As is obvious from the graph, since 1997 the index of public companies engaged in education and training programs has steadily increased over the past 10 years. The slight decrease was stipulated by the dotcom crisis in 1999-2000. It is worth noting that the crisis lasted for about three years (fig. 1), however, the index of "Education and Training" sector recovered just in a year. This fact proves the interest of investors in education sector. Over the next 10 years the index increased by over 600%. However, since 2004 the graph flattens out, and the period from 2010 to 2013 is marked by a steady decline of the index almost by 50 percent. Investors began to lose interest in e-learning sector.

China Online Education Group (COE), online English language learning resource, is a case in point. The company staff consists of more than 2500 employees. In June, 2016, the company entered the equity market and conducted IPO (initial public offering). As a result, the company attracted about 300 million dollars. However, the share of institute-related investors, the stock owners, accounts for 7 %. To compare, the share of institutes in the companies of the sector, which entered the equity market more than 10 years ago, make up 80-90%. This example illustrates the fact that investors began to consider the negative trend and carefully invest in the companies offering traditional products.

This can in part be explained by the economic crisis. However, investment analysts

Fig. 1. Dynamics of index growth in "Education and Training" sector and Standrt&Poor's 500



also indicate other reasons which relate to the peculiarities of education sector development. One of these reasons is a great number of free education programmes and open source software. This issue was addressed by marketing guru M. Porter in the article "Strategy and Internet" in 2001 [1]. The economic model of distributing free content leads to the situation when most profits are lost in the intermediate parties: communication service and internet providers. Due to monetization solution of online content, they deprive real producers of profit that they could spend on product development. However, as it turned out, free content, lack of reliable intellectual property protection, a wide range of piracy are not the greatest problems of online education. Investors believe that a steady decline in income from e-learning presents much greater problem. The investment analysts state three main reasons for this negative trend: damping of education services, too many standards and rules for applying e-learning in higher education system, and, the most important one, low interest of young people in traditional modes of e-learning, namely, electronic books [2]. The first two problems can be solved at political and economic levels. The solution of the third problem can hardly be achieved without introducing innovative technologies into education.

3. Competency development and turn of education towards innovations

Innovations in engineering e-learning encompass several activities:

3.1. Micro-knowledge as a trend of engineering education

One of the ways to innovate e-learning technologies is to transform traditional courses into a set of so-called micro-knowledge. Simply speaking, micro-knowledge is a brief answer to one of the question covered within the course. The traditional lecture course is, as a rule, a continuous test with figures, formulas, and schemes. The lecture course based on micro-knowledge consists of numerous questions and corresponding answers. In fact, it is one and the same learning material, but it is represented in a different form. As is known, the form learning material is given plays a crucial role in education.

Cognitive scientists long ago gave attention to the fact that maximum concentration of a person on this or that question lasts from 6 to 10 seconds. To hold somebody's attention, it is required to constantly switch to something new within the discussed issue.

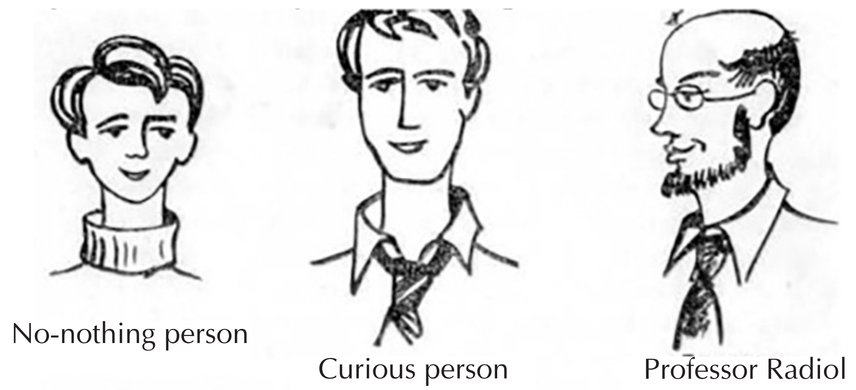
Such approach has been used in cinematography for a long period of time. It seemed that it would be possible to capture the entire dialogue from both characters using one camera (as it was done in old films). In modern cinematography, scene is shot from three or four perspectives followed by assembling the shots so that long shots change every 5-10 seconds.

Division of lecture course into numerous questions and delivering them in terms of micro-knowledge sets are not absolutely new technology. As early as the 1970s, E.Aisberg, a French science communicator, published a book "Radio – but it's so easy" ("La radio? Mais c'est trиs simple!)" [3]. The book material is presented in a form of a conversation between a student and a professor (fig. 2). Due to the innovative approach to transmitting knowledge, this book was twenty-seven times reprinted in France and translated into 14 languages. Such popularity proves the fact that learning materials presented in a form of micro-knowledge, firstly, are rather effective and, secondly, attracted millions of readers who voluntary paid for their self-education. The latter is of particular significance in terms of the disputes about attracting investments and additional financial support into the education sector.

Since the first release of the book more than 40 years have already passed. Only mow, the teaching technology in a form of micro-knowledge has become an innovation in modern engineering e-learning. Such long period was absolutely necessary as this technology could be hardly applied within traditional education mode. The difference in teaching mode is absolutely natural. Traditionally, 2 or 3 questions are discussed during a lecture. It is difficult to image a lector giving the lecture which covers 20-30 separate topics. However, it does not mean that it is impossible to introduce micro-knowledge technology into traditional education system. Precisely, at National Research Nuclear University MEPhI this technology has been implemented in a form of interactive tests to assess knowledge acquisition [4]. Such tests allow instructors to assess the quality of knowledge acquisition in real time. Students knowing about a simple test at the end of the lecture are more motivated to listen to the lector more attentively.

The examples of using teaching technologies based on the micro-knowledge principles are all over the Internet. First of all, it is microblogs, messengers, and knowledge bases. One of the types of micro-knowledge is a frequently-asked- question page crafted by many websites. Modern students belong to the generation of people who grew up with the Internet. In everyday life, they seek and find most information and knowledge in

Fig. 2. Visual technology of transmitting knowledge by means of a conversation (E. Aisberg, a French science communicator, published a book "Radio – but it's so easy")



the global net, and it is this net that forms their peculiar type of information reception. This is actually one more argument for introducing micro-knowledge technology into e-learning. Obviously, the micro-knowledge technology is not a panacea for solving all problems related to the negative trends in e-learning. Alongside all the positive sides of this technology, there are certain limitations. It is not effective or it is almost impossible to use micro-knowledge technology in cross-disciplinary dimension, creative work, art direction, practical training, music teaching, painting, and many other disciplines when not only knowledge but also psychological readiness is important for making decision, for example, while assessing the risks in a real time in the security sector or stock trading within a certain trade session. At the same time, micro-knowledge technology is rather effective for most engineering programmes.

3.2. Animation in shaping competencies while studying dynamic systems

Animation is an ideal tool for explaining engineering processes, procedures, and dynamic systems. With animation, lectors are no longer required to spend much time and effort to describe and explain the statistical diagrams and schemes. For students there is no need to visualize the dynamic process presented in diagrams. In this regard, animation significantly facilitates information reception by making it intuitively comprehensible and simple. In some disciplines, for example, field theory, for a student it is rather difficult to visualize information acquired by means of a verbal channel. In such cases, animation becomes increasingly important.

When introducing animation into education, it is essential to consider a number of limitations. Precisely, overuse of animation at the lecture may result in a contrary effect: students start absorbing information much worse. Cognitive scientists explain this fact by a number of limitations that human brain has, namely incapability of human brain to perceive rapidly changing pictures. In such cases, repetition, slowdown or descriptive texts are recommended. In addition, traditional lecture could be delivered in a multimedia format.

Obviously, for the years of practice most faculty members have elaborated their own format of information delivery including the number of questions to be covered at a lecture, time to be spent on each question, and the number of illustrations to be provided. In the course of lectures, they are in contact with students and are able to estimate the way students absorb information, which illustrations are easy for comprehension and which ones require additional explanation.

Development of e-courses, when a lector is replaced by an animated character, is the next stage in introducing animation into the education. There are several causes which stipulate such innovative trend. Firstly, it is simplicity and availability of numerous animation software. Secondly, it is the cost. This is particular true for the content developers. They often have to negotiate everything with a lector, refine or even develop new visual materials, tackle issues dealing with a copy-writer, rights in the end product, royalty, etc. Thirdly, it is personal characteristics of the lector himself/herself. For media programs, diction, the pitch of a voice, physical description, style and behavior pattern are of significant importance. On television and at various international exhibitions famous actors have been frequently invited as lector-popularizers. Animated characters are intended to perform almost the same role. Finally, such innovations in e-learning as virtual classes, game-based learning programs, simulators, and augmented reality have also significantly contributed to the discussed trend. All these innovations in some way deal with 2D and 3D models, which make them much easier for comprehension and reception.

As it was mentioned, there are a lot of various animation software. The most advanced and popular are as follows: CrazyTalk, iClone, DAZ3D, GoAnimate, Toon Boom, etc. Let us consider the possibilities of CrazyTalk as an example. It does not necessarily involve the knowledge of software engineering. To create an animated character, it is required to choose the suitable image, i.e. drawn character or real people. If necessary, it is possible to use own materials: illustrations, 2D-models and photographs (fig. 3).

CrazyTalk and iClone include special modules which automatically sync lip movement with imputed sound adjusting to various facial expressions (fig. 4). Animated video is created by combining the image, imputed sound, and facial expression in the editing module. Interestingly, the voice can be imputed through microphone or by printing the talking script. The special module Text-to-Speech (TTS) converts normal language text into speech and saves it as a file. TTS modules allow quickly and effectively developing various education programmes without attracting professional commentators. Engineering issues disclosed by such animated tools are easy for comprehension, which, in turn, hastens development of the required competencies.

CrazyTalk allows converting 2D-objects into 3-D ones, however, for this purpose it is better to use 3-D animation programs such as iClone and DAZ3D. These programs allow freely designing and assembling rather real animated characters (fig.2). They include gesture and motion modules developed using 3D-scanners and special sensors which are put on a real person. It allows 3-D models to gesticulate, move and speak as real prototypes.

The last versions of the described software have export module for 3-D models which allow using the developed models not only for animated videos, but for engineering training games.

The growing consumer interest in engineering training games has been given early attention by game developers. They intensively invest money in this sector and actively compete for the market share. A new term “gamification in education” referring to a new trend has been even introduced.

3.3. Gamification as a method to shape competencies within engineering programmes

The idea to use games in education process is not new, however, the entry of available, rather cheap and simple-to-use software stipulates the real boom in development of game-based programmes. The recent studies conducted in various research laboratories have revealed that efficiency of game-based programmes is 15-20 percent more than that of traditional ones. The game-based programmes are more actively applied in school education. According to the report from Project Tomorrow (2016), in 2010 only 23 percent of teachers used game-based programmes in teaching process, while in 2015 this share increased to 48 percent.

Fig. 3. Animated characters (2D and 3D-models) from CrazyTalk and iClone libraries

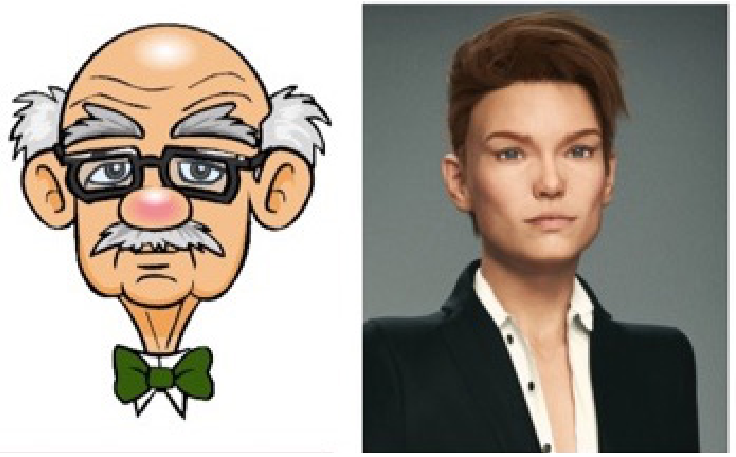


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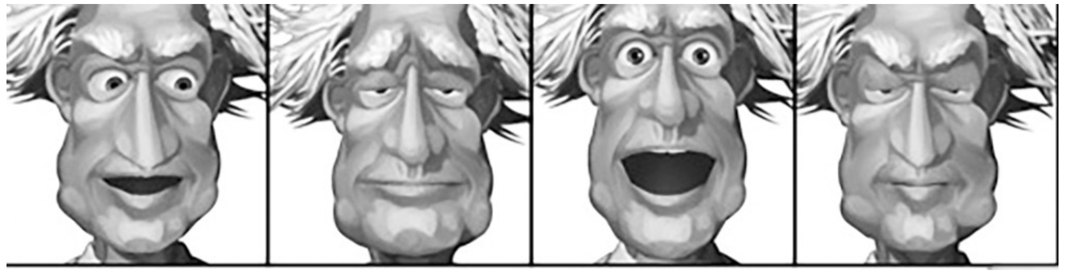
Fig. 4. Example of syncing imputed sound and facial expressions in CrazyTalk.



In the opinion of most experts, games are introduced into education within the two main modes: gamification and the use of training games. What is the difference? Gamification is the use of game principles in non-game activities. For example, students are taught by means of interactive teaching material when it is possible to interact, pass the tests, monitor students’ performance and move forward the next grade by means of mobile gadgets. All these tools are taken from the game industry and efficiently applied in education. American company GoGo Lab developed software program Rezzly (earlier 3D Lab), i.e. a set of services for course design based on gamification mode.

Another mode is development of training games. Most of well-known game developers have designed special software for developing education programmes. Precisely, Unity, a world leader in a game development sector, designed a special product Unity Educator Toolkit intended to be used as a tool to develop education programmes. The company provides opportunity to freely train how to use the tools of a new product, as well as offers discounts on education programme development tools.

Microsoft has also developed a new application Education Edition to its popular game Minecraft (the purchase price of game developer, Mojang company, was 2.5 billion dollars). By means of this application, educators can design the game activities related to the studied discipline including problem solving standards, interactive hints, statistics on student performance, etc.

4. Simulation in e-learning and engineering education

At the end of the 1990s, simulation was regarded as an absolutely urgent technology. This kind of innovation plays a crucial role in developing control systems for complex technological processes. Writing a software code was considered one of the basic problems that impeded introduction of this technology into education. To solve this problem, significant resources, investments and time were required. Modern simulation software includes a number of modules, each of which is intended to solve one of the typical modeling problems. Such software primarily includes iThink (www.iseesystems.com) [5] and AnyLogic (www.anylogic.ru). Working with this software is like Lego: a researcher has to build the studied model like from Lego units (fig. 5).

Simulation is starting to play significant role in education. The developed simulation software packages have become laboratory platforms for students to conduct various experiments, which is of particular importance in implementing and advancing e-learning.

4.1. Technology Chatbot in shaping engineering competencies

Lately the chatbot technology gains more and more popularity mainly thanks for the innate capabilities of the automation technologies and the widest outreach to

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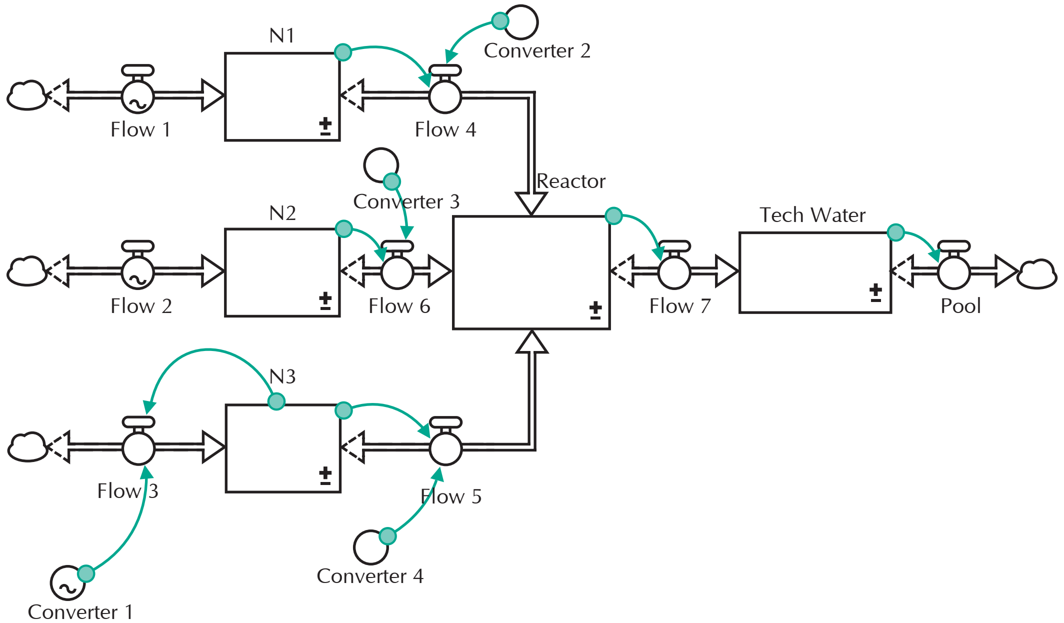
Fig.5. iThink simulation model for shaping engineering competencies



the audience [6]. In particular, about 700 million users per month take advantage of WeChat services. This innovation originated in business. Large companies have used such service as phone-tree (type of chatbot) for a long time. Practically everyone making a call may have heard: "If you have a question about – please press 1, if you are interested in ... – please press 2, etc. Thus, Chatbot is an interactive technology which is based on certain rules. A student poses a question, and computer-educator provides the answer. However, another version is also possible: a student is asked questions, while computer has to assess the answers. This technology has become widely applied in teaching foreign languages. English language school "Wall Street English" applies Chatbot technology in its multimedia e-learning courses. Due to this technology, more than 200000 students from 29 countries are annually enrolled into the school courses. In engineering education, the technology is not widely applied, it is all ahead.The first consideration of implementing new technologies into education is given in [7].

4.2. Globalization of engineering education programmes

Globalization is one more trend in engineering e-learning. Large players on the IT-technology market have not been spared e-learning boom. Such companies as Google, Microsoft, Apple have been developing their own e-learning courses for a long time. However, one of the main tasks of these companies is to become providers of a full set of services required for designing and disseminating e-learning courses. Having significant technological, informative, and financial resources, these companies are capable of designing and promoting a full set of services required for developing e-learning courses. In this case, users would have opportunity to freely take the advantages of the provided services, while the companies get profit from the monetization solution of online content: developers will be able to sell their content (training courses) by means of global online retailers of these companies giving them part of their profit.

5. Conclusion

Sustainable development of "Education and training" sector could hardly be secured without significant investments. Initially, investors invested significant amounts of funds into the companies dealing with design and dissemination of e-learning services and products. However, since 2010 the interest of the investors in this sector has declined. This fact can be explained by a number of reasons: availability of numerous free content, lack of reliable intellectual property protection, a wide range of piracy, damping of education services, too many standards and rules for applying e-learning in higher education system, and, the most important one, low interest of young people in traditional modes of e-learning, namely, electronic books. To reverse this trend has become possible due to innovative engineering inventions. The modern e-learning sets dramatically differ from traditional ones: digital books and training materials. In competition for education market, the companies actively apply innovative approaches implementing the latest inventions in the field of engineering information technologies and cognitive sciences. Simulation, especially simulation of technological processes and equipment, micro-knowledge principles, gamification, animation, augmented reality, chatbots and a number of other technological approaches are among the most widely spread innovations in e-learning.

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Motivational Types of Professional Retraining Programme Attendees

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Abstract
Demand for education is consistently high in Russian society. Apart from basic higher education, various retraining programmes account for a large share in service sector. The main goal of the retraining programme on Managerial Personnel Training for National Economy (the President programs) is to teach people having primarily engineering education how to manage a modern company. The article examines basic motivational types of retraining programme attendees. Knowledge of motivational types and ways of defining them are required for education programme design, however, this problem is currently neglected, which results in poor education quality..

Key words: motivational type, entrepreneur, demand for education, behavior peculiarities, education peculiarities.

Focus on market mechanisms in Russian economy is a factor that indicates radical changes in public life and shapes new understanding of civic position in psyche of people, i.e. the role of an active player in the economic activity. Over the years, the author of the current research has studied the motives to choose business activity instead of dependent employment [1]. The work as a management consultant, educator in MBA programmes and the Presidential Management Training Programme (training of managerial personnel for the organizations of national economy), and business trainer contributed to regular interactions and information exchange between entrepreneurs of Tyumen and Tyumen region (the study involves the data on Tyumen and Tyumen region). The frontier of the research is 6 years (2010-2016).

The respondents are primarily from Tyumen Petroleum University, most of them having higher education and being in need for management retraining.

Respondents' characteristics are listed in Table 1.

Motivational theory of Gerchikov was taken as a basic method of the research [2, 3]. The Motype test created by V.I. Gerchikov, observation method and diagnostic interview were used. Initially, there was no purpose to provide classification of entrepreneurs of Tyumen region. The test was conducted to familiarize the programme attendees with the opportunities of motivation methods. Only in the third year of the research, we noticed the regularity in respondents' responses and motivational types. Therefore, we started conducting the same test almost in all groups of programme attendees.

Motivational theory of Gerchikov suggests two mutually exclusive motivational types: achievement and avoidance. People of the first motivational type work in order to achieve the set goals that may be money (instrumental type), professional growth (professional type), independence in choosing work performance tools, duties

Table 1. Characteristics of respondents-attendees

№	Indicator	The number of persons	The number, %
1.	**Industry:**		
1.1.	Civil engineering	43	12
1.2.	Production of consumer goods	21	6
1.3.	Transport service	29	8
1.4.	IT-service	57	16
1.5.	Service for business sector (juridical, tax, marketing consulting, ad services)	32	9
1.6.	Medical service	36	10
1.7.	Oil, gas and petroleum product production and selling	53	15
1.8.	Telecommunications	18	5
1.9.	Bank and finance services	14	4
1.10.	Wholesale and retail trade	25	7
1.11.	Food services	21	6
1.12.	other	7	2
2.	**Business size:**		
	small	133	37
	mid-sized	198	56
	large	25	7
3.	**Trainee status**		
	business owner	78	22
	hired director, a stockholder	64	18
	hired director having no share in business	153	43
	head of department	32	9
	work performer	25	7
	other (unemployed)	4	1
4.	**Sex**		
	male	258	72
	female	98	28
5.	**Age**		
	up to 30 years	42	12
	31-35	68	19
	older than 35	246	69
	Total	**356**	**100**

and applied efforts (host type), and affiliative orientation (patriotic type).

The employees of the second type do not want to work and consider work as a punishment. The main motives are horror and avoidance of horror. V.I. Gerchikov characterized this type as lumpen one. As a rule, pure motivational types are rare, therefore, our purpose was to identify the predominant type and the difference between the types combined in a personality.

At the first stage of the research, it was revealed that host motivational type prevailed in the attendees who are the owners of mid-sized business in real sectors of economy (civil engineering, transport, production of consumer goods). It was obligatory followed by instrumental type. The combination of these two motivational types was registered in 91 % of cases. The lumpen and patriotic types were almost absent (2-3%). Other motivation types were also registered.

Table 2 presents the averaged motivational type of an entrepreneur.

For convenience, we use abbreviated names of the motivational types:

(I) – instrumental type, motivation is material side of reward;

(P) – professional type, the motivation is interest in professional activity. The work which is not interesting is done with low efficiency;

(H) – host type, motivation is freedom in goal setting, with goals are not necessary coinciding with the goals of a company;

(Pat) – patriotic type, motivation is recognition, sense of purpose, efficiency of combined efforts and work;

(L) – lumpen, motivation is comfort, avoidance of punishment, the main value is to get settled in life.

The combination of the first types is of particular interest. The more obvious combinations are as follows: HI (host – instrumental), HP (host-professional), PI (professional-instrumental), IPat (instrumental-patriotic), HPat (host-patriotic), IL or LI (instrumental-lumpen), and etc. The described types are most common.

Among business owners and hired directors-stakeholders, the host-instrumental type is predominant. Such entrepreneurs prefer having their own business to dependent employment as the latter can hardly provide them with the required income. Activity areas are as follows: wholesale and retail trade, civil engineering (100% of entrepreneurs demonstrate this type), transport service, food service (this type prevails). The peculiarity of the HI type is favoring short-term profit over strategic development. Due to this peculiarity and owners' interests, investment projects with long-term payback period are a rare case in these spheres.

The host-professional type dominates in the following spheres: medicine, bank and finance service, IT-services, services for business. This type of entrepreneurs significantly differs from the other ones. Business is set up for the purpose of self-fulfillment as dependent employment is not interesting. The most common phrase of such type of entrepreneurs is: "I do not want to do silly job and execute unnecessary orders". The entrepreneurs of this type like to learn, introduce innovations often even to the detriment of income. They do not perfectly work in a team (business games) and do not understand opinions of other participants. This type of business owners is prone to conflicts working in joint projects even despite the obvious benefits of various points of view.

The analysis of hired directors having no share in business has revealed that professional-instrumental and even instrumental-lumpen types are the most common in oil, gas and petroleum product production and selling. The main motivation of PI type is an opportunity for self-fulfillment and satisfaction of material needs. People who do not want to take risks and are ready to suffer certain limitations from business owners in order to have interesting and well-paid job are more often become hired directors. In a case of type change depending on the relation towards the property, the behavior of the hired

Table 2. Basic motivational types of entrepreneurs

№	Industry	295 resp.	Business owner		Hired director, a stockholder		Hired director having no share in business	
			Motivational type	Intensity, %	Motivational type	Intensity, %	Motivational type	Intensity, %
1.	Civil engineering	33	HI	100	HI	100	IH	85
2.	Production of consumer goods	19	HI	84	HI	100	IP	76
3.	Transport services	23	HI	89	HI	77,8	IH	60
4.	Services for business sector	27	HP	100	PH	75	PI	77
5.	Medical service	33	PH	100	HI HP	60 40	PI	69
6.	Oil, gas and petroleum product production and selling	34	–	–	–	–	IL	59
7.	Bank and finance services	12	PH	100			PI	75
8.	Wholesale and retail trade	23	HI	100	IH	78	–	–
9.	Food service	21	HI	75	HI	67	PH	72,7
10.	Telecommunications	10	HP	75	–	–	PH	100
11.	IT-service	57	PH	62	PI	67	PI	83,3
12.	Other	3	–	–	–	–	IP	100

directors who are frequently work to the detriment of the company becomes clear. Firstly, directors of this type seldom take risky decisions (otherwise he would work "for himself/herself"); secondly, they make a choice on an "interesting-uninteresting", "useful-useless" scales. In our opinion, it is the root cause of conflict between business owners and hired directors, which results in desire of business owners to lead their companies by themselves.

The instrumental-lumpen type among hired directors work in oil and gas production and selling sector accounts for 59 %, which is the evidence of demand for certain supervisors' attributes in this market sector. These attributes include: conservatism, abidance by a certain order (even out-date one), strict subordination, unconditional obedience. These attributes are of great use in well-predicted environment, however, in modern conditions they contribute to low innovation development and imitation of innovation activity. Vocational programme attendees who work in this field do not differ from work performers. The exceptions are directors of fuel-filling stations. They are open to any kind of innovations, especially in the service sector.

At the second stage of the research, test results and analysis findings carried out among the selected attendees (department heads and work performers) were examined. The comparison of the results has revealed that motivational types of business owners and employees significantly differ. The averaged motivational type of department heads and work performers is given in Table 3.

Table 3. Motivational types of attendees who do not belong to the category "entrepreneur"

№	Industry	61 per.	Department head		Work performer		Other	
			Motivational type	Intensity, %	Motivational type	Intensity, %	Motivational type	Intensity, %
1.	Civil engineering	10	IPat	62,5	IL	100	–	–
2.	Production of consumer goods	2	–	–	IL	100	–	–
3.	Transport services	6	IP	67	LPat	100	–	–
4.	Services for business sector	5	–	–	PI	80	–	–
5.	Medical service	3	PI	100	IP	100	–	–
6.	Oil, gas and petroleum product production and selling	19	IL	94,4	LI	100	–	–
7.	Bank and finance services	2	IP	100	–	–	–	–
8.	Wholesale and retail trade	2	–	–	LI	100	–	–
9.	Food service	–	–	–	–	–	–	–
10.	Telecommunications	8	–	–	LI	87,5	–	–
11.	IT-service	–	–	–	–	–	–	–
12.	Other	4	–	–	–	–	PI	75

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It was surprising to find out that lumpen type (L) is frequently registered among work performers, including lumpen-instrumental (LI) and lumpen-patriotic (LPat) ones. The exception is service sector where people are often rather enthusiastic and not oriented to high salary in comparison with those working within other sectors.

The most common motivational type in oil, gas and petroleum product production and selling is the lumpen type, heads of departments accounting for 94.4 %. The revealed fact definitely requires empirical evidence and additional studies. However, the difference in motivational types is significant and partially explains moderation of innovative development in production branches of the national economy.

The motivational types always affect performance efficiency. In addition,

Table 4. The preferred motivational types depending on the occupied position and expected results

№	Peculiarities of working conditions	Expected results	Position (example)	Motivational type
1.	Emergency cases related to vehicle breakdown, weather conditions, subordinates' attributes	Contract conclusion, search for activity areas	Owner of motor transport enterprise	HI
		Contract execution in a cost effective manner	Head of motor transport enterprise	PI
2.	Stable and effective work, female competition, dependent on location	Customer attraction, brand recognition increase, low operation cost	Head of fuel-filling station	PI
3.	Legal limitations, need to speak "common language" with various people	Customer attraction, brand recognition	Head of pay-hospital	PPat
4.	Severe competition, constant search for new customers	Customer attraction	Business representatives	I
5.	Stress, need to satisfy requirements of various customers (authority, students)	Performance of the planned amount of work on time and with the required level of quality	Teaching staff	PatP
6.	Legal limitations, work within the time lines, accuracy	Performance of the planned amount of work on time and with the required level of quality	Accountant	LPat

working conditions are often very important. For example, the lumpen type can be rather effective in stable conditions and strict hierarchy.

Table 4 illustrates preferred motivational types depending on the occupied position and expected results.

The use of motivational types in labor-management relations is typical for personnel management. It is reasonable to advance the current research by analyzing the desired motivational types and/or their selection at the stage of education. While testing students, it has been revealed that motivational types fully develop by the end of the third year of education. The motivational type affects student's success and attitude towards education.

A student of host motivational type is striving to follow his/her learning path and build partnership relationship with an instructor. A student of professional type demonstrates good academic performance only in the disciplines that are interesting, and this type is the most sensitive to innovative teaching techniques. Students of the lumpen type demonstrate the worst academic performance and quite often negatively respond to innovative teaching techniques. This type is not likely to change. Any type could evolve to the closest one. For example, the lumpen type will never become the host one, however, the latter could demonstrate the attributes of the former under certain negative conditions.

Motivational theory of Gerchikov might be applied for resolving a wide range of tasks which are not necessary related to personnel management. As the studies of the motivational types, especially their combinations, were not finished by V.I. Gerchikov, the empirical research in this sphere is relevant and urgent. In our opinion, research aimed at revealing peculiarities within certain market sectors, especially in real economy where motivation is neglected in comparison with engineering competencies and skills, is of particular interest.

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UDC 316

Popularity of Engineering Professions: Results of Sociological Survey

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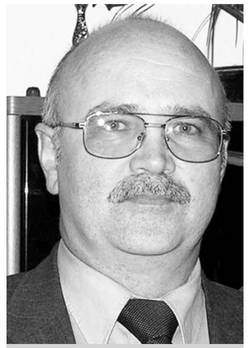

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Abstract
The article discloses an analysis of the current state of school students' interest in scientific and engineering majors – a comparative analysis of the popularity of engineering professions and university majors among youth based on the results of sociological surveys and informational and analytical materials of higher educational institutions efficiency monitoring.

Key words: sociological survey, majors, engineer, engineering specialties, interest.

Engineering education today is one of the priorities of the governmental policy in the sphere of education, which reflects the need for technological upgrade of Russian production industry and development of corresponding workforce for the industry.

Nowadays, attraction of high school graduates to receiving engineering education is one of the most topical tasks for modern Russia.

It is evident that in the current conditions there is a need for analyzing the issue of students' interest in scientific and engineering majors, which can permit development of actions for qualified satisfaction of both, the demand of the youth interested in engineering education, and the need for resourcing of Russian industrial sector with highly qualified specialists.

According to the data of various sociological surveys, graduates of Russian high schools tend to choose engineering and technical specialties with an increasing frequency, whereas before the higher interest was shown towards law and economics. These results have been discussed on various national meetings of executive agencies managers in the sphere of education of the Russian Federation constituent entities [1].

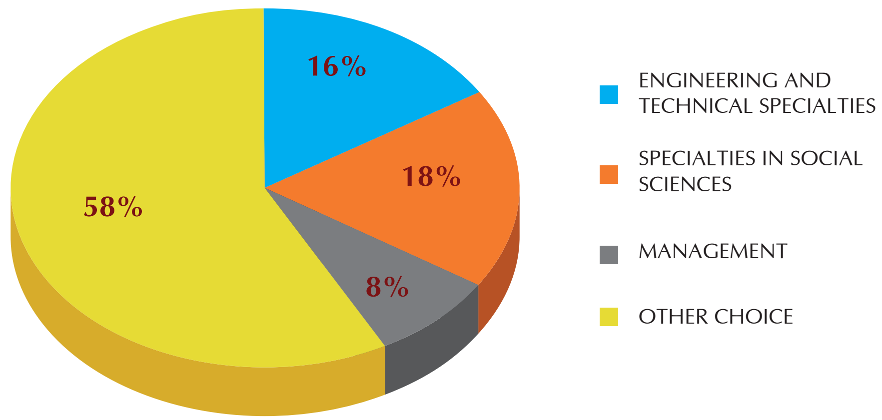
For instance, a sociological research has been conducted by Saint-Petersburg State Budgetary Institution "Center for Promotion of Employment and Professional Orientation of the Youth "VECTOR" in 2015 among 18459 students of 9th and 11th grades from 272 general education institutions of Saint Petersburg. The following results have been received (Fig. 1).

At the moment6 graduates of 9th and 11th grades of general schools knowingly choose engineering and technical area; the proportion of this choice is almost equal to the choice of Social Sciences.

Modern-day students neither want to get higher education simply for the purpose of a diploma, nor do they want to "suffer on labor market while looking for an unwanted job" [3]. At least, this is the conclusion made by the researchers of State Unitary Enterprise "Saint-Petersburg Information and Analytical Center" [3].

Thus, in the result of the 2015 poll, according to the high school students' perceptions the top among well-paid professions is the profession of an engineer. Every fourth young person believes that it is the engineering diploma that will ease the process of finding a worthy job in the

Fig. 1. Results of sociological research on popularity of majors among school students of Saint Petersburg in 2015

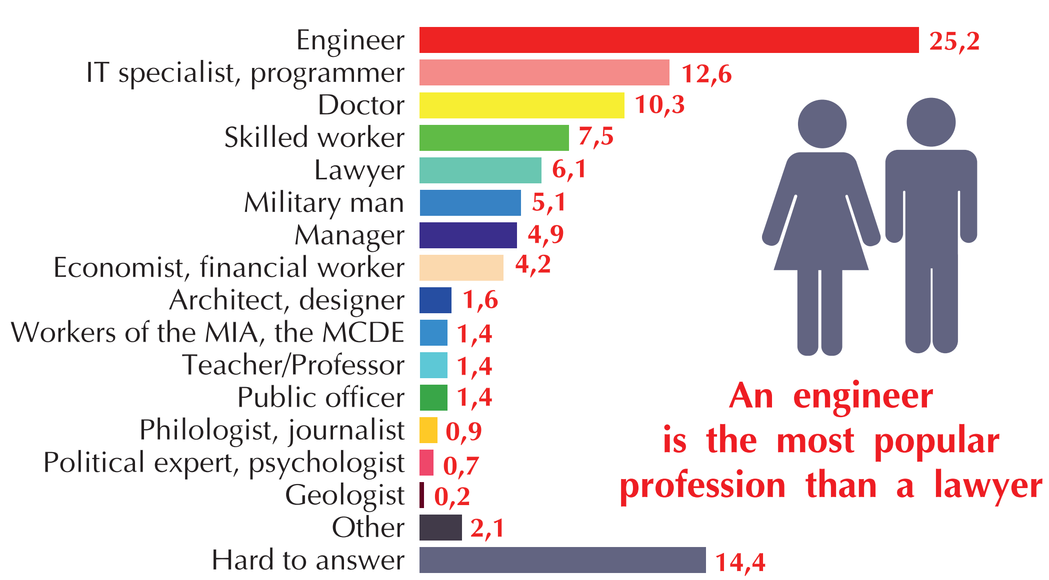


years to come. The second place in the rating of high school students' preferences is the profession of a programmer and other specialties in IT. They are followed by doctors and skilled workers (Fig. 2).

A comparative rating of professional preferences (Table 1) has been prepared as a result of the sociological research conducted by Saint-Petersburg State Budgetary Institution "Center for Promotion of Employment and Professional Orientation of the Youth "VECTOR" [2].

Among technical professions the most popular is the profession of an engineer with various specializations. In 2015 it has been chosen by 1770 students (9.6% of the respondents). It is followed by IT-specialist (4%), architect (1.5%), automotive serviceman (1%), and programmer (0.6%).

Fig. 2. Distribution of responds to the question "with which professions it will be easier to find a worthy high-paid job in the years to come", % of responds



Where Workers of the MIA, the MCDE - Workers of the Ministry of Internal Affairs, the Ministry for Civil Defense, Emergencies and Elimination of Consequences of Natural Disasters

Table 1. Comparative rating of professional preferences (by professions) according to the sociological research

Profession 2007	Profession 2010	Profession 2015
IT-specialist	Doctor	Engineer
Doctor	Teacher	Manager
Automotive serviceman	Lawyer	Economist
Teacher	Manager	Doctor
Economist	Designer	Teacher
Lawyer	Cook	IT-specialist
Accountant	Engineer	Lawyer

In line with the increased interest of youth towards receiving higher education in engineering majors, the number of budget-funded places in universities has been increasing for several years. Results of enrollment campaigns of the past years indicate that the interest keeps rising. There are more and more professionally oriented young people among first year university students, who entered universities with an aim to receive prestige specialties [4].

The choice of IT specialties is as popular among Russian high school graduates.

In May 2016, Zoom Market agency conducted a sociological survey among high school graduates of 2016, who were planning to enroll in HEIs, to identify their choice of faculty and future specialties [5]. Among the respondents there were 1900 high school graduates of 2016 from 19 cities of the Russian Federation. The respondents were graduates in the age of 16–17.

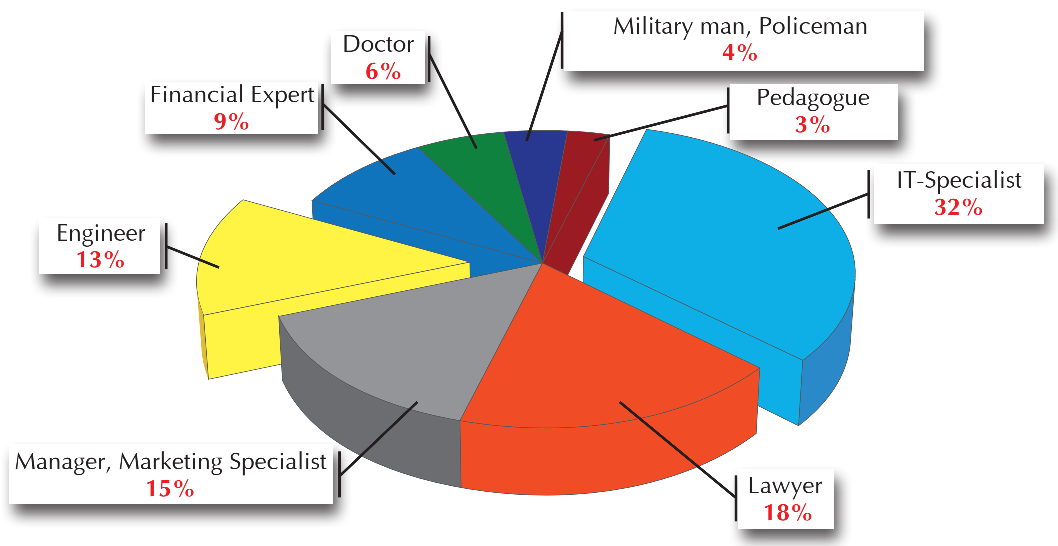
The survey indicated that the majority (32%) of high school graduates prefers IT-specialties (programmer, web-designer, system administrator), the second popular choice is law. 18% of the respondents want to be lawyers. The third choice is given to management and marketing (15%). 13% of the respondents want to become engineers, whereas 9% would like to enroll to financial faculties (most popular specialties are: financial manager, accountant, financial director). 6% of the graduates want to get involved in medicine (surgeons, dentists, pharmacists). Building careers in law enforcement agencies interests 4% of the graduates (military, police and other agencies). No more than 3% of the respondents are willing to enroll at faculties of Social Sciences (philology, history, psychology, philosophy, pedagogy) (Fig. 3).

Thus, the results of the analysis demonstrate positive trends connected with the rise of popularity of engineering majors, whose graduates are in demand by the real sector of economy. At the same time, due to relatively complex technical disciplines, certain dispositions of enrollees, as well as other reasons, socio-economic majors still represent quite a common choice.

Students' interest in engineering majors in different regions has been analyzed with the use of Informational and Analytical materials of the conducted efficiency monitoring of HEIs [6]. Students' allocation according to the knowledge areas in Moscow and Saint-Petersburg are presented on the pictures 4 and 5.

Rectors of the leading HEIs of Moscow believe that enrollees are changing their attitudes towards the choice of professions trying to determine precisely what they will be doing tomorrow. Therefore, they lean

Fig. 3. Results of a sociological survey by Zoom Market agency among high school graduates of 2016, who are planning to enroll in HEI; choice of future specialty



more and more to the real economic sector, the industry, understanding that the future of the country is in advanced industry.

Keen interest in engineering specialties has been noted not only in HEIs of the two major cities, but also in the outlying regions.

Starting from 2015, HEIs of Khanty-Mansi Autonomus Okrug (Constituent entity of the Russian Federation, Ed.) underline the following trends in their enrollment campaign: enrollees show great interest in engineering specialties, whereas the interest towards economic majors has decreased significantly (Fig. 6).

Students' interests, for instance, in Surgut State University have changed significantly. In 2015, the demand towards engineering specialties has been unprecedented. The quota for budgetary places for these specialties has been increased extensively comparing to the previous enrollment campaigns. At the same time, the number of paid enrollees for economic majors, which have set popularity records in the past decade, has decreased substantially comparing to the previous years. Focus on engineering specialties and their active propaganda show positive results [7].

In 2015, the number of students enrolled on engineering specialties in Pensa HEIs has increased on average by 8.4% comparing to the previous year [8].

Monitoring of the Unified State Exams (USE) in Pensa oblast (Constituent entity of the Russian Federation, Ed.) in 2015 showed that subject-oriented disciplines of engineering and technical classes became more demanded: over 80% of high school graduates chose USE on proficiency mathematics, the average grade for USE on physics has increased significantly (18% more comparing to the results of 2014). These are the results of Pensa oblast's active development of the system for schools students' engineering education, whose aim is to meet the needs of the regional labor market, to provide qualified engineers, IT-specialists, technicians, designers for enterprises.

Allocation of students according to knowledge areas in Pensa oblast is presented in fig. 7.

Around 30% of the respondents of the survey see these majors as a priority for themselves. The survey has been conducted by KMG Company on the request from Kalinigrad Regional Agency for Youth Affairs at the end of last year

Fig. 4. Students' allocation according to knowledge areas in Moscow

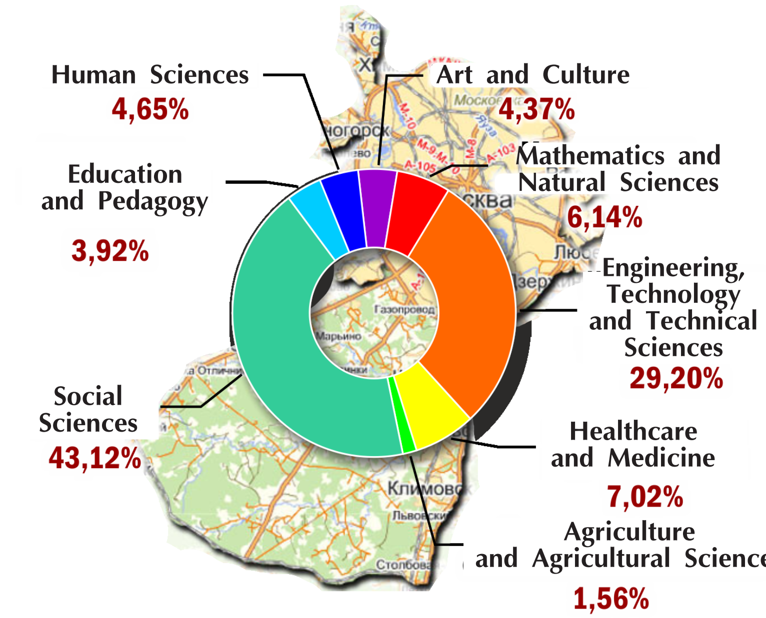
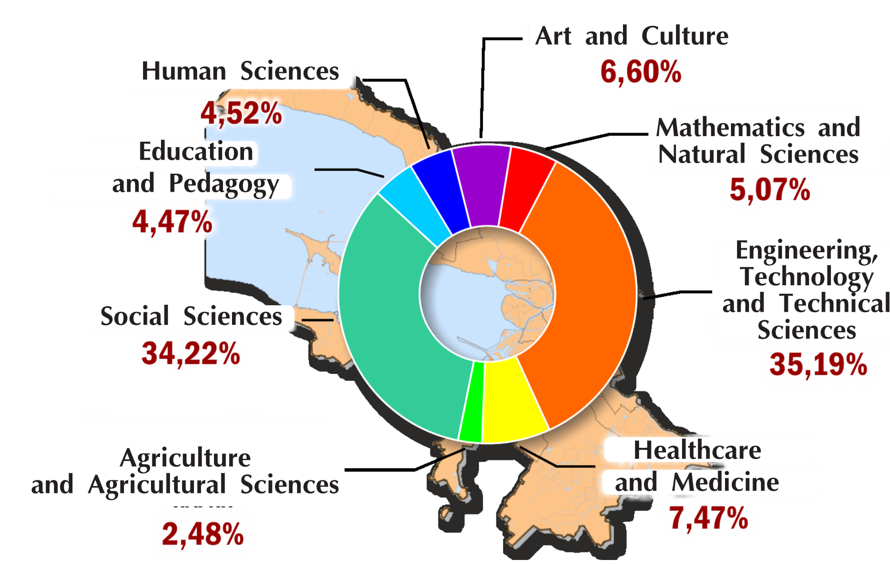


Fig. 5. Students' allocation according to knowledge areas in Saint-Petersburg



among youth of 14-30 years old, who live full-time in the region. The study showed that 20% of the respondents think that getting technical or engineering education is more prospective; another 10% choose financial and economic majors; and 10% choose law. A noticeably lower part of youth chooses professions of doctors, pedagogues, military men and programmers – around 6% each.

Fig. 6. Students' allocation according to knowledge areas in Khanty-Mansi Autonomus Okrug

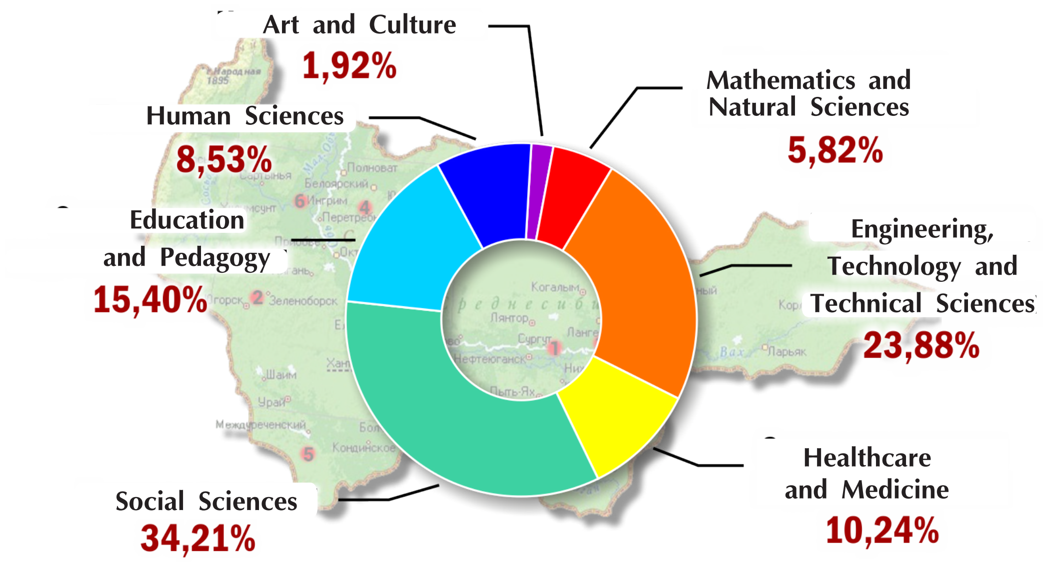
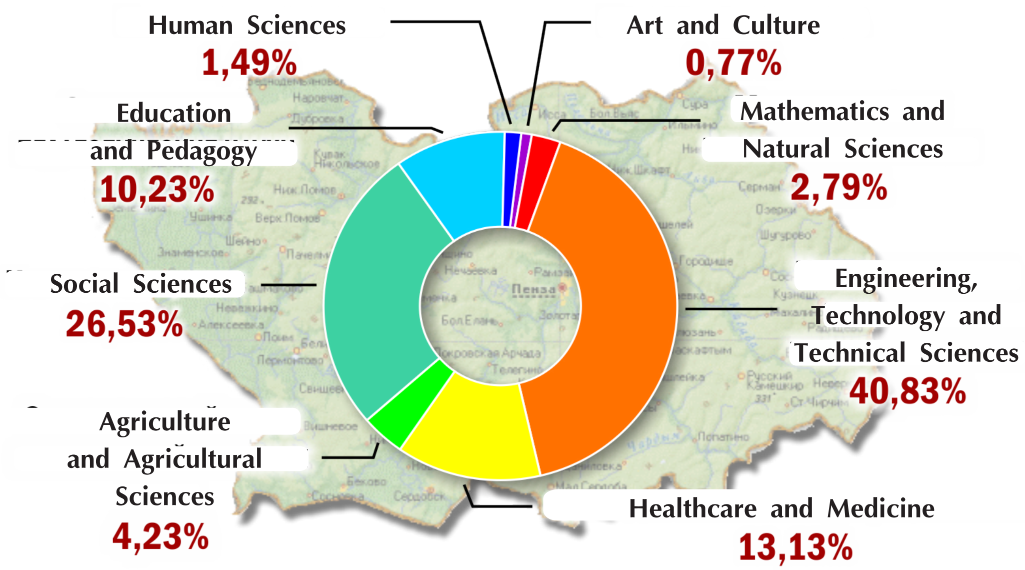


Fig. 7. Students' allocation according to knowledge areas in Pensa oblast



Allocation of students according to knowledge areas in Kaliningrad oblast (Constituent entity of the Russian Federation, Ed.) is presented in fig. 8

In Tyumen oblast (Constituent entity of the Russian Federation, Ed.) the results of the USE-2015 indicate that higher interest of graduates lies at the root of the exact sciences [10]. Allocation of students according to knowledge areas in Tyumen oblast is demonstrated in fig. 9.

This is due to the changing preferences of youth in their choice of future place for education: enrollees far more actively choose engineering specialties, which fully corresponds to the needs of the regional economy. Labor market has been overloaded with lawyers a couple years back, and has

Fig. 8. Students' allocation according to knowledge areas in Kaliningrad oblast

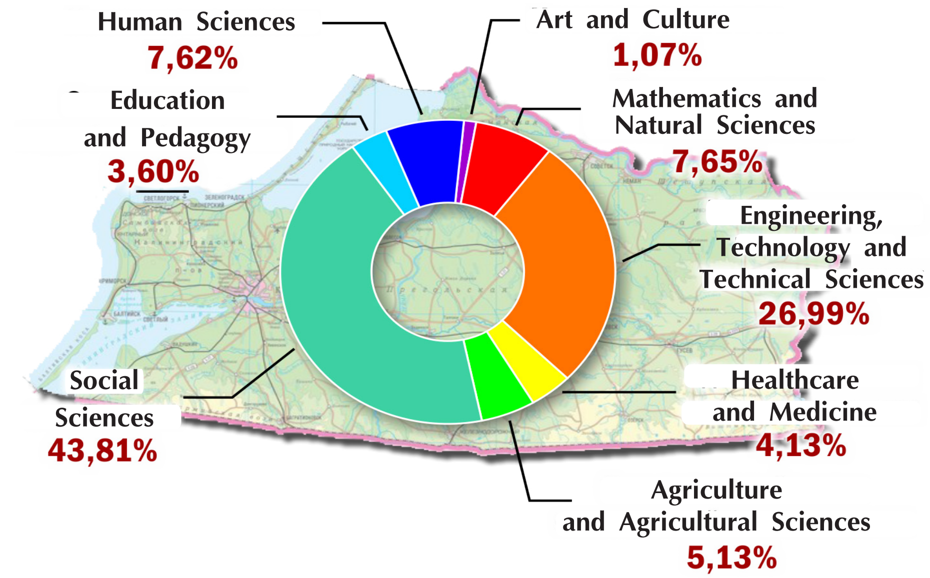
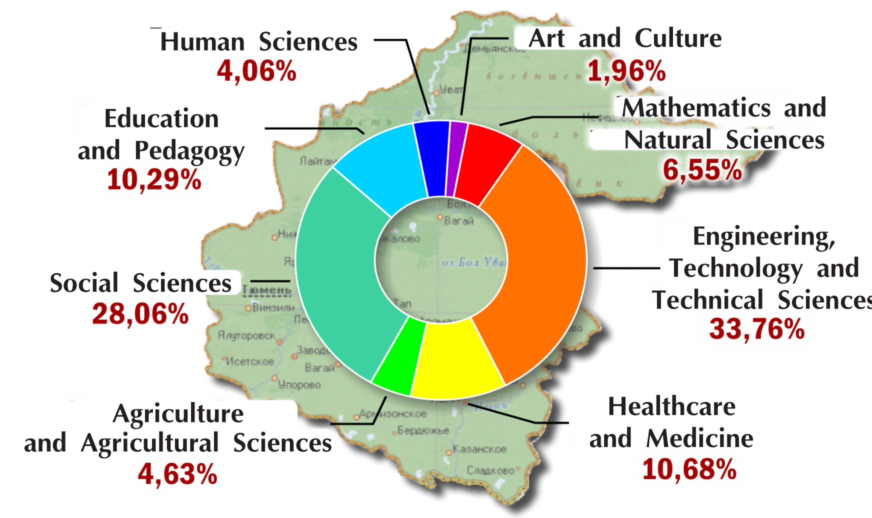


Fig. 9. Students' allocation according to knowledge areas in Tyumen oblast



shown a severe shortage of engineers. Today young people understand that by having a technical education they get more chances to find a good job; therefore they choose physics for their USE.

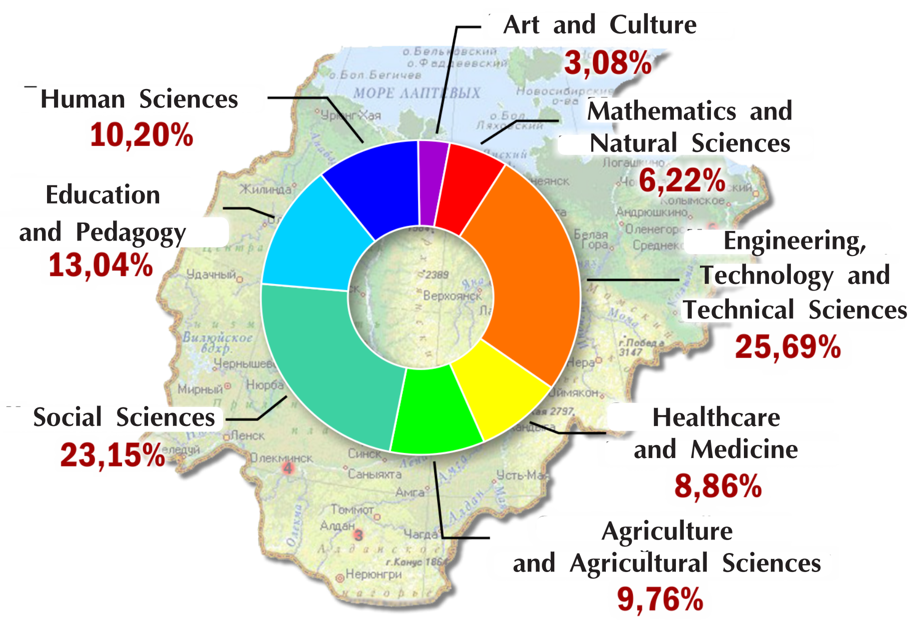
Sakha Republic (Constituent entity of the Russian Federation, Ed.) enrollees also tend to become engineers, emergency response workers and programmers [11]. Allocation of students according to knowledge areas in Sakha Republic is shown in fig. 10.

Sakha high school graduates strive to study on engineering specialties and to receive blue-collar jobs. Thus, in 2015, the most prestige specialty among enrollees was the "Technical Maintenance and Service for Radioelectronic Technology" (11applicants per 1 budgetary place).

The majority of the leading universities are located in the European part of Russia, mainly in Moscow and Saint-Petersburg. However the demand for specialists is as distinctive in other territories.

According to Vladimir Putin, the President of the Russian Federation, education has to be fully complied with the industrial production. At the same time, it should be understood, which industrial sectors will become the driving force for the development of territories, such as Ural, Siberia, Far East and Arctic Region [12].

Fig. 10. Students' allocation according to knowledge areas in Sakha Republic



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ENGINEERING EDUCATION: TRENDS AND CHALLENGES

ENGINEERING EDUCATION 22'2017

A.A. Kozlova

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UDC 378

The Balanced Scorecard as a Tool to Develop Business Education at Leading University

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Abstract

The article deals with the relevant issues concerning innovative development of education system. It describes the role of business education in development of innovative economy. The role of the Balanced scorecard in enhancing business education is defined. The Balanced scorecard performance indicators for a leading university are evaluated.

Key words: innovative economy, business education, Balanced scorecard, strategic management, performance indicators.

Introduction

One of the main peculiarities of the 21st century is the transition to the knowledge-based economy which is characterized by information society, converting information into the source of economic growth and excess profit. Security of the State is inseparable from the economic prosperity of the nation, while labor force is a main industrial factor, index of innovative development of the economy. Therefore, the task of each person is as effectively as possible to apply his/her knowledge and acquire new one by means of education.

This kind of behavior towards investments into human capital should be supported by the government, as it is one of the most important tasks of the economic policy of any developed country. Put it otherwise, today human capital should be regarded as a main factor of economic growth as aging of knowledge is as rapid as information updating. Therefore, there is need for continuous staff training, long-life learning based on new technologies and education programmes that meet the requirements of the present economy. Investments into the human capital is a multilevel process. However, it is required to define the role of the balanced scorecard in development of business education. Improvement of university efficiency is one of the main tasks that faces university rectors. One of the main conditions for developing competitive university is revision of business education. This area of education should be constantly updated in terms of technologies, innovations and rapid adjustment to the needs and requirements of the ever-changing world. High-quality education is still one of the most significant life values of citizens and determining factor in securing social justice and political stability.

1. The role of business education in innovative development of economy

Business education is a professional education which implies training people who are involved in management of various companies operating under the market conditions and focusing on profitability.

Today, in the system of higher education one of the most important aspects that secures functioning of the entire systems is assurance of such conditions when universities meet the most relevant and urgent requirements of the society. To improve the efficiency of university management and advance the area of business education, there is a tool which is applied as a Balanced scorecard system. This system is based on the cause-effect relationship between strategic goals reflecting their parameters and factors that influence achievement of the results. Therefore, one of the main issues relating to university development is university efficiency improvement and effective application of its intellectual and scientific potential for securing constant updating of the national economy. This problem can be also solved by developing business education and activating integration of universities into real sector of the economy.

Today, the balanced scorecard system based on the cause-effect relationship between strategic goals reflecting their parameters and factors influencing result achievement is a promising tool of strategic management.

2. Economic tools for planning education development

The Balanced scorecard is a system of strategic enterprise management which implies the assessment and evaluation of its efficiency on the basis of a set of optimally selected indicators. The indicators reflect all the aspects of enterprise performance: financial, manufacturing, marketing, innovative, investment-related, managerial, etc.

The Balanced scorecard is a tool for strategic management which allows linking business unit performance with its strategy. It reflects the balance that should be secured between short-term and long-term goals, financial and non-financial indicators, basic and supplementary parameters, as well as external and internal performance factors.

According to the aspects of business unit performance, the interlinked indicators are formed. These indicators supplemented by the system of personnel evaluation and motivation are applied at all the levels of the business unit structure – from the top to the bottom. In this case, it is possible to define financial aspect as a basis of the system, while customer one – as a priority of the system. It happens so because it is the customer aspect that is able to show success in achieving the goals set by the university authorities (fig. 1).

Focus on consistency and harmonization in the strategic management is a crucial methodological principle that allows improving management efficiency. The basic idea of the Balanced scorecard is to balance the system by means of four integral elements or criteria.

1. Finance. It is a traditional part of almost any model of management efficiency evaluation. Predominately, it is of particular importance for commercial organizations, however, it can be adjusted to the specific features of a company, namely university. In this case, this criterion is no longer the most significant one.

2. Custome. According to the Balanced scorecard, this criterion is considered with regard to the market sectors within which the organization operates, in our case it is a sector of education services. When it comes to higher education, this criterion becomes the most important one, as its values show success in achieving the goals set by university authority. The client criterion includes several basic indicators which are crucial for the undertaken strategy. They are as follows: customer satisfaction, expansion of client base, volume and share of target market sector.

3. Internal business processes. Based on the indicators of this criterion, internal processes which affect customer satisfaction and financial goal achievement are estimated. According to this criterion, innovative processes are regarded as an integral part of organization performance. For any organization, regardless of the economic sector concerned, ability to manage the development of new products and services, as well as possibility to attract new clients may become more crucial for success achievement in the long term in comparison with the effective management of the existing process.

4. Education and personnel develop-ment. This criterion defines the infrastructure to be created in order to

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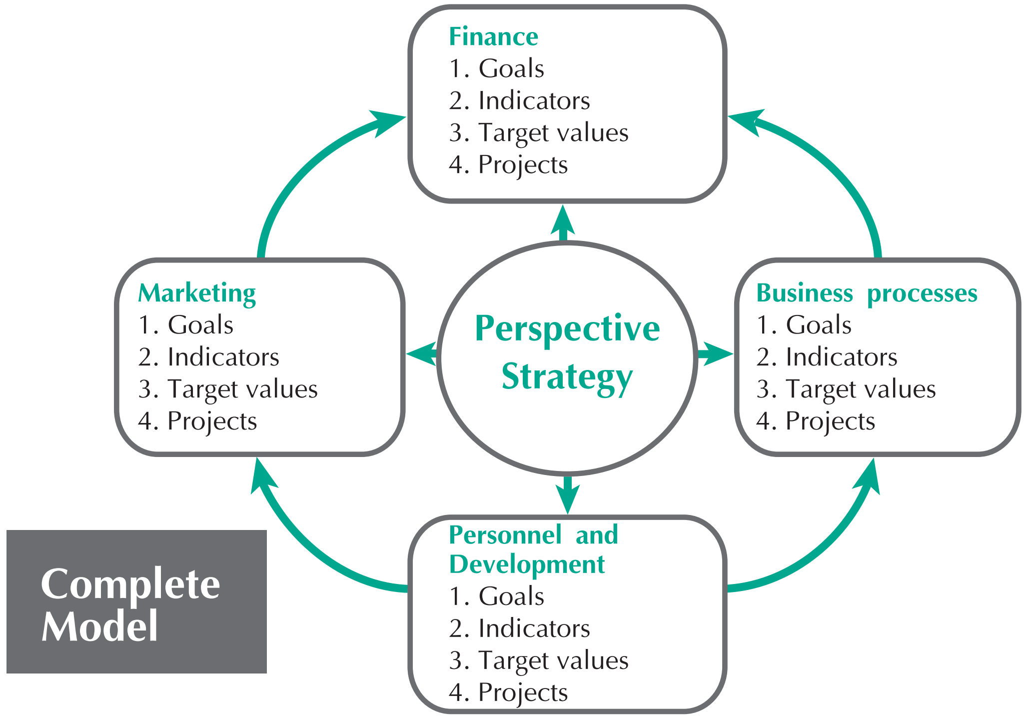
Fig. 1. Complete model of Balanced scorecard



secure the growth and advancement of organization in long term. The above-described criteria incorporated into the system include the indicators that are the most significant for development of present and future business processes ensuring organization performance. However, it is impossible to achieve long-term goals using only present-day technologies. Therefore, it is required to provide corporate education aimed at enhancing personnel qualification and their career growth. According to the education and personnel criterion, there are three main sources of formulating goals, tasks and indicators within the entire system of organization's goals and tasks: people, systems and organization's procedures. Based on the earlier-described criteria, a significant gap between people, their abilities, systems, procedures and the required breakthrough is identified. To eliminate the gap, it is necessary to invest in retraining and personnel development, continuous enhancement of the applied technologies, information transmitting and processing systems, development of relationship mechanisms between strategic goals and everyday procedures. This last criterion is intended to link all the aspects of organization performance, which is of particular importance in terms of building and implementing the balanced system in the organization. Like indicators of the client criterion, indicators of education and personnel development are a set of general indicators, such as job satisfaction, staff turnover, education and personnel development costs, and specific indicators related to the certain activity. It is often a set of skills and abilities that personnel should have in a rather competitive environment. The time lag in receiving information about clients and internal business processes which are essential for taking strategic and tactic decisions is an indicator of possibility to enhance the information systems.

3. Goals and tasks of education system innovative development

The main goal of the Balanced scorecard system is comprised of the following tasks:

- do develop such management system that allows systematically implementing strategic plans by converting them into the language of operations management and monitoring the strategy implementation by means of the key efficiency indicators;
- to elaborate efficiency indicators for high-level managers including the tasks and indicators of low-level managers according to the structural-functional approach;
- to implement the strategy by effective functioning of all departments which are managed by means of planning, control and analysis of the scorecard, as well as personnel motivation;
- to eliminate the gap between organization's goals and their operational implementation, as well as rapid response to the changes;
- to link the organization's goal with personnel activity.

The origin of Balanced scorecard can be traced back to 1990 when Nolan Norton Institute suggested developing performance indicators for organization of the future as the existing approaches to assessing organization performance had been already outdated. The project was supervised by David Norton, a director of Nolan Norton Institute, and Robert Kaplan. During the first year project members and representatives from numerous companies (financial, manufacturing, service, heavy industry and high tech) together discussed the content of a new performance measurement model. They examined various innovative systems of performance evaluation, revised and improved them. Alongside enhancement of the traditional indicators, namely, business activity indicators, absolutely new ones were developed: customer delivery times, quality and cycle times of manufacturing processes, new product development efficiency, enhancement indicators, team-work indicators, indicators of leadership efficiency, etc. In the course of project implementation, numerous ideas about the content of indicators were proposed. For example, there was an idea to consider the indicators of value creation for stockholders, however, the researchers came to the conclusion that multi-functional system of organization performance evaluation is the most optimal one. It was further termed as "Balanced scorecard system" and was comprised of four main elements: financial, customer, internal, and innovation and learning (fig. 2).

The Balanced scorecard is not just a simple system to monitor, evaluate and improve personnel performance, it is a serious analytical tool, implementation of which requires much time and effort. However, it could allow organization leaders and top-managers to achieve the desirable results and focus their efforts within a highly competitive environment of the present.

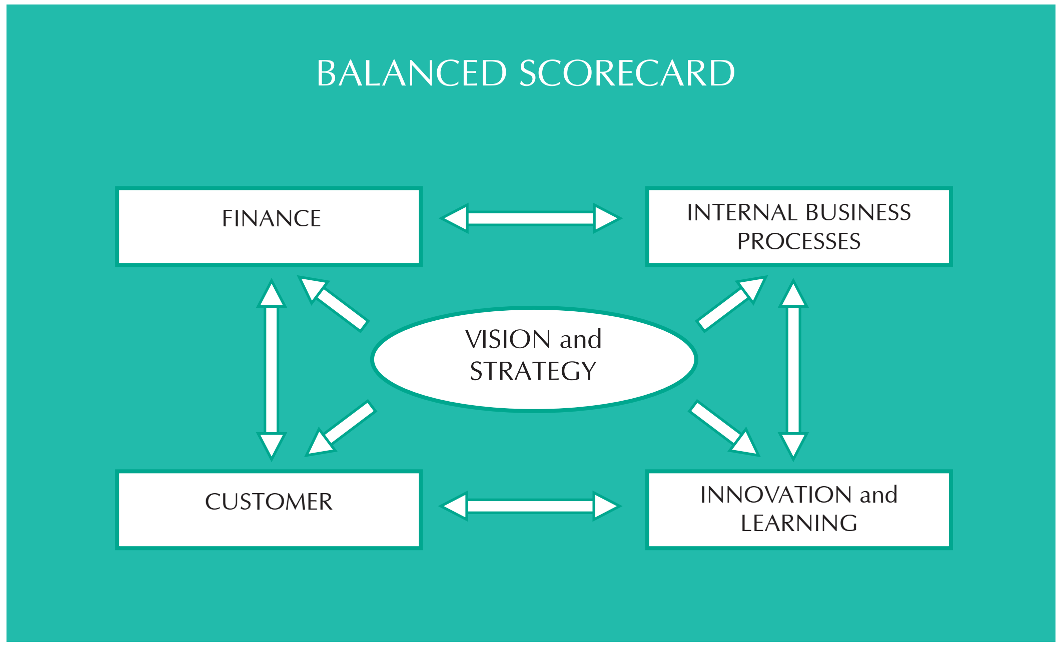
Due to the Balanced scorecard, it is possible not only to analyze the financial results, but also to generate new possibilities and regulate acquisition of intangible assets for further growth.

Today, enterprises related to various market sectors are at the very epicenter of revolutionary transformations. The epoch of industrial competition is currently being replaced by informational one, when the main focus is put not on making maximum profit at minimum cost, but on the implementation of new information technologies, optimal and effective use of intangible assets, integration of business processes, management enhancement, etc.

Thus, the Balanced scorecard enables managers to bring together the strategy of organization and a number of interconnected indicators developed for each management level. The main intended purpose of the system is to enhance business strategy by translating it into a comprehensive set of measures, involving each employee, constant monitoring and feedback in order to trace and generate initiatives inside the structural departments.

The main idea of introducing the Balanced scorecard into university deals with presenting of university's strategies in terms of the indicators of effective goal

Fig. 2. Elements of the Balanced scorecard



achievement (fig. 3). The system of indicators serves as a coordinate system, in which goal is formulated as targets for key performance indicators and strategic plan is compiled as a trajectory towards the goal in time. In this case, the Balanced scorecard serves as a trajectory towards effective implementation of business education programmes.

4. Experimental evaluation of Balanced scorecard parameters for leading university

To develop the Balanced scorecard, it is required to identify its integral blocks and describe them in accordance with the peculiar features of State autonomous education institution (table 1).

In this model the finance element is the basic one which secures achievement of the goals within the other blocks of the Balanced scorecard. The main focus would be put on the customer block and industry. The latter implies interaction with the companies with regard to the joint educational and research activities.

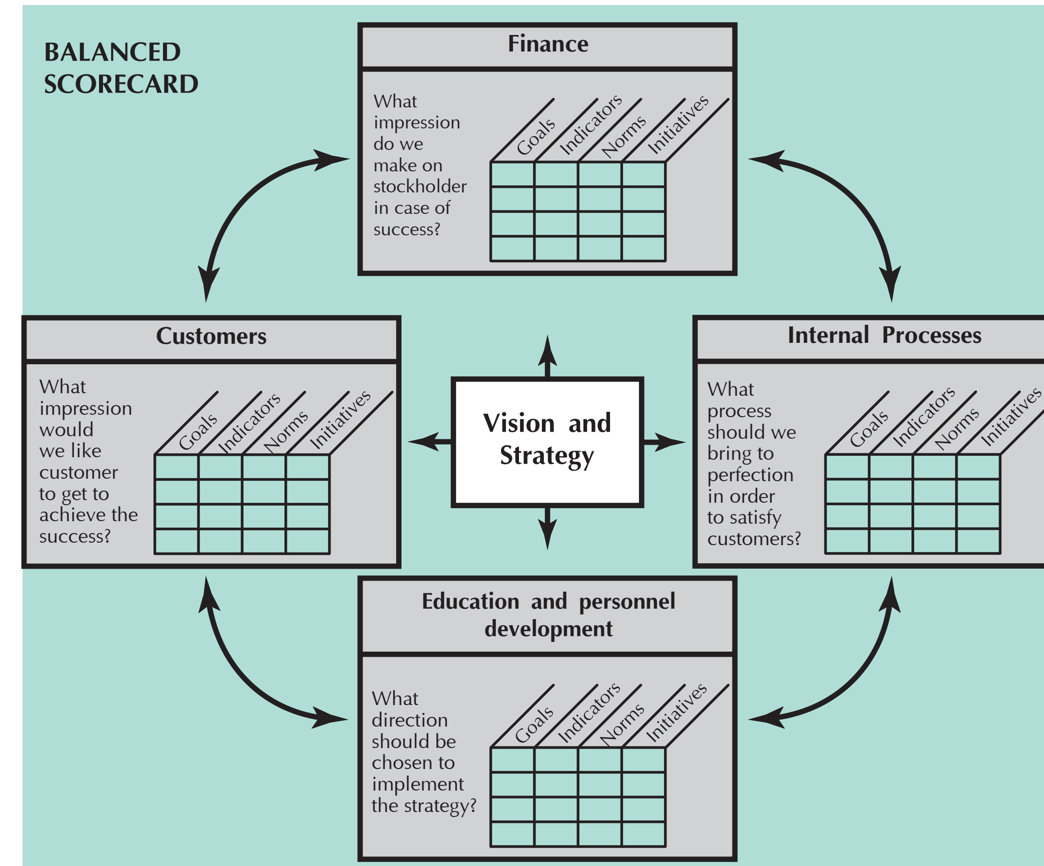
Customers:

- Implementations of measures aimed at supporting students, post-graduates, trainees, young scholars and faculty staff.
- Introduction of new education programmes in cooperation with the leading foreign and Russian universities and research institutes.
- Enforcement of measures to attract students from leading foreign universities to study at Russian universities by means of joint education programmes and university associations, as well as to attract school leavers who demonstrate creative skills and interest in research.

Industry:

- Implementation of measures to attract young people who have already gained experience in research and teaching activities at the leading foreign and Russian universities, as well as research institutes.
- Research in accordance with the long-term program for basic scientific research at the universities of the Russian Federation and priorities in the international fundamental and applied research.

Fig. 3. Balanced scorecard for university



Internal processes:

- Implementation of measures to enhance post-graduate and doctoral programs.

Personnel:

- Enforcement of measures to form the candidate pool of university top-managers and attract specialists to the top positions who have working experience in leading foreign and Russian universities and research institutes.
- Implementation of international and internal Russian mobility programs for university staff in terms of internship, advanced training, professional retraining, and etc.

The Balanced scorecard is developed on the general bases and implies converting of the university strategy into the goals, indicators, norms, and initiatives within each block (table 2). The strategy of National Research Nuclear University "MEPhI" is to become a global leader in education, science and innovation, precisely in nuclear, radioactive, information, nano-scale, biomedical technologies and their engineering, as well as to significantly contribute to developing state corporation "Rosatom" and other Russian leading high-tech companies.

The indicators which characterize each block of the system are set for each goal. Based on these indicators, the strategy map of the Balanced scorecard is built. It is a model which brings together intangible assets and value creation.

The analysis of the Program of increasing competitiveness up to 2020 and possible

Table 1. Balanced scorecard elements, targets, and indictors for National Research Nuclear University "MEPhI"

№	Balanced scorecard elements	2015 (performance)		2016 (performance)		2017 (target)	
		at the expense of subsides	at the expense extrabudgetary resources	at the expense of subsides	at the expense extrabudgetary resources	at the expense of subsides	at the expense extrabudgetary resources
1	2	3	4	5	6	7	8
1	Industry	0,53	0,51	0,50	0,61	0,35	0,76
2	Internal processes	0,01	0,00	0,01	0,00	0,01	0,00
3	Personnel	0,23	0,05	0,31	0,09	0,38	0,09
4	Customers	0,23	0,44	0,18	0,30	0,26	0,15
	Total	100%	100%	100%	100%	100%	100%

ways of cooperation between "MEPhI" University and business structures (state corporations, leading scientific centers, companies and enterprises) makes it possible to predict the share of business education within engineering education programmes. By the example of "MEPhI" University, this share should account for 10-15%. It has been revealed that there is an urgent need for elite engineering staff, interdisciplinary specialists focused on implementing international business projects into nuclear industry. The road map includes the relevant chapter (2.1) which presents the norms and regularities for international project implementation.

Conclusion

In modern conditions, only those universities which are ready to introduce more effective and innovative tools of strategic management can survive and effectively operate in the market of higher professional education. The Balanced scorecard is one of such tools. The current study was aimed at clarifying the way to implement this system in order to develop business education.

The Balanced scorecard system has been successfully used in commercial sector. The findings of the study have revealed that the Balanced scorecard could be adjusted to the sphere of higher professional education in Russia. Introduction of this system into education has several peculiarities, as it is necessary to consider a number of factors: impact of legislation system; state order, and consumers' needs.

According to the strategy of National Research Nuclear University "MEPhI", the strategic goals have been identified. These strategic goals compose the cause-effect relationship of key efficiency indicators which, in turn, show the success of the entire strategy. The proposed model of the Balanced scorecard demonstrates that achieving one goal would contribute to developing the entire business education. It is proposed to use five main blocks: finance, industry, customers, internal processes, and personnel.

The main conclusion that can be drawn based on the analysis of the Balanced scorecard indicators as a system of strategic

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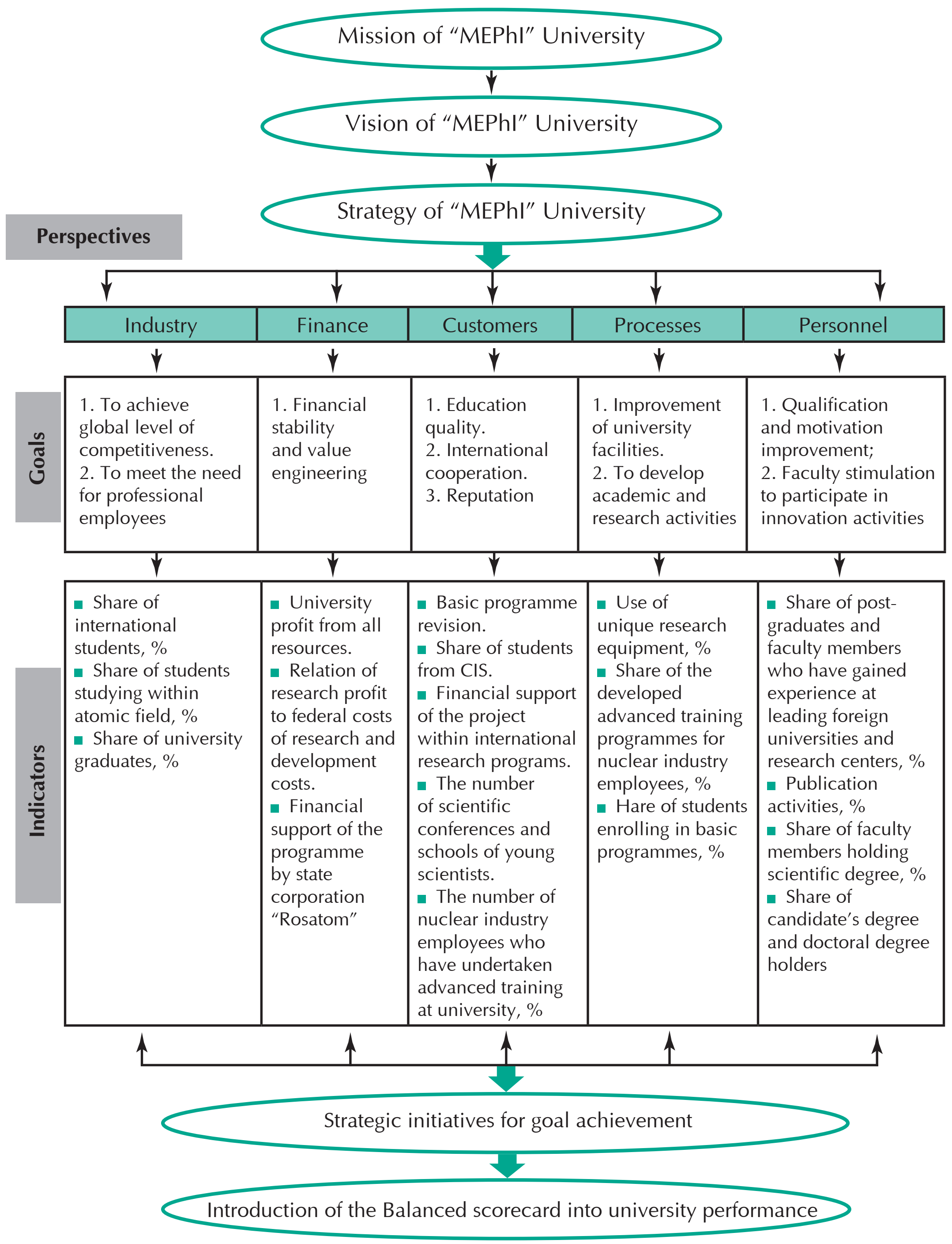
Table 2. Strategic goals according to the integral block of Balanced scorecard for National Research Nuclear University "MEPhI"

Balanced scorecard blocks	Strategic goals
Industry	▪ to achieve global level of competitiveness; ▪ to meet the need of industry and state for professional employees; ▪ to ensure high quality education.
Internal processes	▪ to develop academic and research activities; ▪ to develop quality management system; ▪ to enhance information support; ▪ to improve university facilities.
Personnel	▪ to provide faculty with constant advanced training and motivation; ▪ to stimulate faculty to participate in innovation activities.
Customers	▪ targeted training; ▪ education quality; ▪ international cooperation enhancement; ▪ service competitive price; ▪ reputation of National Research Nuclear University "MEPhI".

management is that the efficiency of introducing the Balanced scorecard into National Research Nuclear University "MEPhI" is due to the fact that it enables university managers to visualize the development strategy of the university, achieve the strategic goals, which, in turn, contributes to developing business education. The proposed Balanced scorecard can be adjusted to any university.

Fig. 4. Balanced scorecard of "MEPhI" University



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E.V. Kondrashova

UDC 378

"Your Future Starts Today": First-Year Students' Insights in Engineering Professions

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Abstract

The article considers the connection of professions of the future with engineering, what first-year students think of their future engineering job and what demands are made by future engineers today to do their job successfully in future. The article reveals the future specialists' principle requirements as well as establishes the key factors of profession selection.

Key words: engineering jobs, engineering education, jobs of the future.

Introduction

The young generation has a great variety of choices in case of future profession selection. The choice of profession can be influenced by different factors: dynasty tradition, job prestige, high salary, and other factors.

Career choice and dynamics of its transformations have an effect on both present and future development of society and country on the whole. Looking back in the past one can remember that many children dreamed of being cosmonauts, hockey-players, doctors. In the 60's of the 20-th century any pupil said that he/she wanted to be a cosmonaut, doctor or teacher. In the late 20-th and early 21-st centuries the juridical and economical specialities gained great popularity.

Usually, the top positions in the list of preferred professions include jobs providing regular income. However, according to the research of Institute of Sociology, Russian Academy of Sciences as well as data by Research Center of Sociological Surveys SuperJob.ru, more than 50% of the youth choose jobs based on the requirement that they should be interesting for them. The second factor influencing the choice is high salary that was indicated by the quarter of respondents. The third and fourth places were correspondingly divided by prestige of a future profession and a chance to bring benefit. Every fifth respondent considers these factors to be important in selection of future job.

The days, when there were few engineers and most strived to be a lawyer or a manager, are gone.

The present determines our future. In its turn, future creates a new generation. The youth strives to realize its potential. This realization is focused not only on regular income and financial well-being, as was shown by the poll.

We live in the era of innovation, which aims at transformation and improvement of the world, the part of which is a man. The human factors and potentials are the current emphasis as they convert the opportunities and turn them into present, traditional, usual things. Those that have been recently considered impossible or fantastic, today are taking shape thank to engineers' activity.

At the moment increased requirements are set for university curricula. During the rapid changes in different spheres, one of the important requirements is "proactive education". It is evident that a key aspect here is a forecast of the most perspective technologies and trends in science and education.

In the nearest several decades, new products and technologies will be designed, for the development of which new specialists will be in demand. The growth of complexity in management systems implies new skills. It is here and now that engineering profession is becoming the most urgent, since it is an engineer who is a man capable of not only taking correct decision, but also foreseeing their consequences in the future. Obviously that the role of an engineer today and in the future is one of the most crucial as the role of innovator, inventor, creator, and developer of new materials and processes, improving technologies etc.

"Your future starts today" and at present those students are taught engineering specialities that will create future. It is suggested to reveal a scheme of factors changing the engineers' tasks in the industries, consider the expected work of the future related to engineering. Besides, it is proposed to establish the ways of first-year students' viewing them, as they will influence the development of engineering in the nearest future.

Research

At the moment the relevant methods of interaction with students to obtain and exchange information are various case studies, surveys and workshops, which allow students' involvement in discussion and obtaining data for visual analysis as, for example, histograms or graphs of target and input variables.

The first-year students, who are taught as engineering staff for information society, were presented the jobs of future related to engineering and potentially associated with the specialities trained by the students.

The professions were composed of different blocks from "The Atlas of New Professions 2.0" [4], where the results of survey were gathered by "Competence Foresight 2030" performed by Moscow School of Management Skolkovo and the Agency for Strategic Initiatives (more than 2500 experts participated in the survey). The professions were proposed from the following blocks: "Safety", "Robotics and Machine building", "New materials and nanotechnologies", "Transport".

The discussion dealt with the results of the Third industrial revolution and expected results of the Fourth industrial revolution.

It should be mentioned that the jobs of the future appeared due to new requirements and factors. Among of the principle factors are: automation, globalization, changes in consumer preferences, new technologies, changes in production, development, service, etc. At this point the engineering specialities are becoming prominent. As was mentioned, in the condition of the New Industrialization there are demands for new approaches towards engineering education in Russia [1].

Although the Third industrial revolution has not spread everywhere yet, in some experts' opinion, the time of the Fourth industrial revolution or "Industry 4.0" has already come, which is proved by discussion of Industry 4.0 at the 46-th World Economic Forum in Davos [2].

Thus, the Fourth industrial revolution implies extensive introduction of cyberphysical systems into production, servicing human needs including labour and leisure. It results in new requirements for work force. As previous industrial revolutions caused labour transformations and employment relations [3], so now one can speak of new generation of work force with updated and improved skills and competencies.

It is expected that many professions are no longer relevant and will completely disappear within several years or decades. For example, "professions of the past", in researchers' opinion, include: accountants, statisticians, analysts, librarians, translators, logisticians, copy-writers, proof-readers, etc.

Taking into account extensive transformations, jobs related to engineering, on the contrary, can be referred to topical ones.

Among the relevant professions of the future proposed for students' discussion were:

- *Smart environment designer* – a specialist taking software-technological decisions for smart environments;
- *Recycling technologist* – a specialist in development and implementation of technologies of recyclable materials, production of new materials from industrial wastes as well as development of zero waste techniques;
- *Ergonomist-designer* – a specialist designing robotic systems in view of consumers' ergonomic requirements taking into account their physical and psychological peculiarities;
- *Domestic robot designer* – a specialist developing and programming home robots (for example, robot dog walker);
- *Composite engineer* – a specialist dealing with composite materials to produce parts including 3D-printing;
- *Transport safety engineer, navy infrastructure engineer;*
- *Expert of system environmental disasters, etc.*

The list of necessary skills and requirements for personnel in the condition of the New Industrialization is rather extensive, but the university graduates do not often meet the requirements for personnel in the global labour market [5].

The students were offered to make a list and highlight the basic skills necessary for engineers. The results of students' opinion are presented in fig. 1.

It should be noted that, in first-year students' opinion, essential skills for the future profession are fluency in foreign language and communicative skills that shows the trend of globalization, including production economic sphere. 75% of respondents pointed out the necessity of awareness in technologies of related and unrelated fields. The histogram below demonstrates a wide range and variety of requirements.

The main factors of profile and future profession selection noted by the students are presented in fig. 2. 70% of interviewed students think that an engineer is a prestigious and highly-paid job. More than 30% believe that their job is interesting and useful for society as an engineer is a link between innovative breakthroughs and scientific discoveries and their practical application.

Results and discussion

After discussion of proposed professions, the students have made several essential conclusions. On the one hand – *engineering professions are recognizable and have similar features in both present and*

Fig. 1. The skills necessary for a future engineer

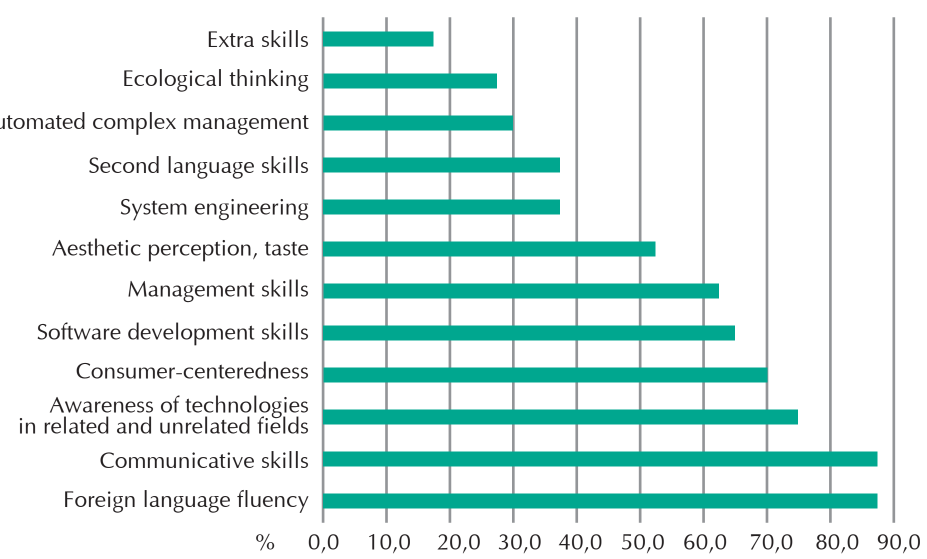
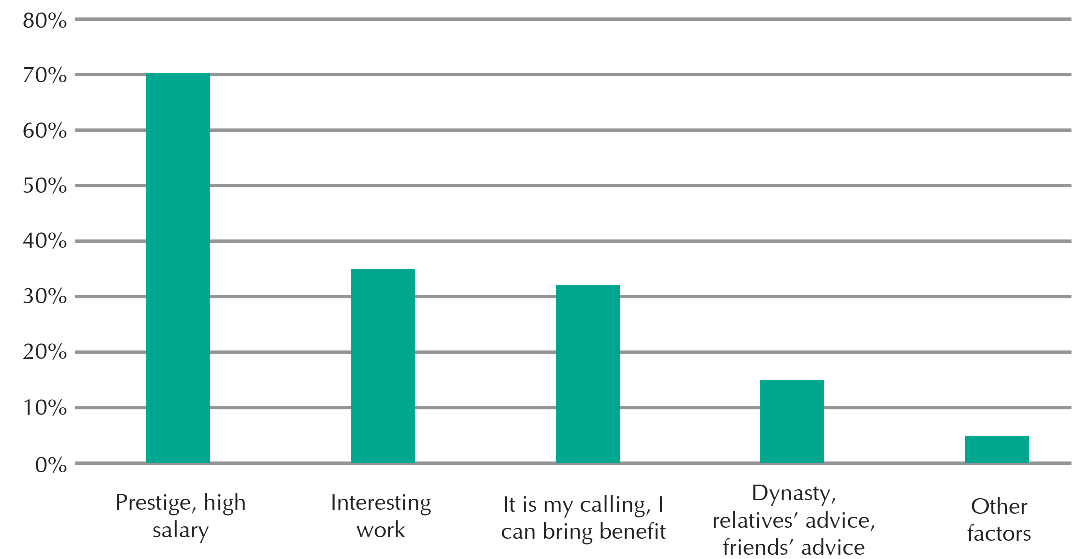


Fig.2. Main factors of future profession selection



proposed new form of future. On the other hand – division of industries is less noticeable, hence, there is a demand for awareness of processes and technologies in related and unrelated fields. More acute is demand for acquiring skills of multidisciplinary communication and work under the condition of rapid changes in solved problems. In addition, it should be noted that all proposed "professions of the future" were accepted by the students as absolutely natural forms of labour. The students expressed their confidence in the fact that these professions have already occupied or will occupy their place in the sphere of new technologies in future. Moreover, most students noted that they can realize their potentials in one of those professions. As a result of discussion students revealed that *one of the typical features of engineering professions is responsibility* for development and application of new technologies and processes.

Based on the data obtained and students' discussion one can conclude that students consider the job of engineer to be in demand and prestigious in the future. However, the choice is also conditioned by the interest in innovative developments and opportunity to be a man valuable for the community.

The students noted the increase in demand for sophisticating systems and technologies and, hence, requirements for himself/herself when training or working in future as a creator or driver of innovative approaches in different spheres of life. Future engineers understand: at present they demand higher standards for themselves and strive to invent and develop new technologies to improve the future. It is here and now that they lay down the foundation for these changes. Thus, the image of new and transformed engineering professions, perception of new competences and labour transformations have already been born in the minds of young people, they define their view of life and set a new development trend.

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Intellectual Guidelines (References) of Engineers in Renovating Modern Production

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Abstract

Engineers lack sound guidelines to identify the level of changes in constructions and technologies. It leads to problems in planning and managing the renovation of modern production. The article discusses guidelines for gradual identification of level of changes in technologies and constructions based on interconversion of object and process systems.

Key words: innovative activity, competitiveness of enterprises, thematic plans of rationalization and invention, level of changes in constructions and technologies, system operation principles.

Relevance of the issue

The world changes constantly. Karl Marx stated: "Everything that is fixed is dead; everything that is in progress is imperfect. The modern dynamic environment requires companies' managers to receive the slightest signal of dangers and possibilities [1]. The signal sources are not only global trends and political events, but technological shifts (new materials, fundamentally new technologies and constructions). This approach is deeply rooted in the strategy of leading companies. The list of actions to manage changes, which is mentioned in the famous work by Igor Ansoff, includes the following points: 1) to create "a launch pad"; 2) to plan a process of changes; 3) to prevent conflicts between strategic and current processes; 4) to plan implementation; 5) to manage current production processes; 6) to institute the new strategy; 7) to maintain strategic response [1].

The areas of innovative activity in modern companies are multifaceted. All their subsystems (social, psychological, technical, economical) need changes. However, it is the technical and technological subsystem that is the dominant area in the structure of changes. Describing the new role of a company director, researchers note that it is the ability to manage continuous sequence of technological steps that determines the company's survival [2].

Currently Russian economy is not in the best state. A lot of companies are looking for investments all over the world to upgrade their production cycle, though there are resources inside the companies. The portal "Production management" provides the opinion of a German consultant in production management, who states that Russia has lost the rationalization system that the Germans once learnt from [3]. The necessity to restore this activity is proved by the leading companies ("Votkinsky zavod", "Proton-PM", "Russian Railways", "Taifun", "NEVZ", "Kirovsky Zavod" etc.) [4–7]. It is a very important issue. There are a lot of examples in the Russian history when the state pays special attention to the area of invention and rationalization even in the hardest period – the Great Patriotic War [8].

The current synonyms for "rationalization proposal" are "Kaizen proposal", "total production optimization", "improvement proposal" and even "Stop losing!" (Russian branches of Alcoa) [3, 9]. Each of the terms has its particularity, however there is the only aim – to stimulate staff initiatives, to find inner resources and make them work for the sake of a company.

However, the experience of the leading Russian companies [10] proves that management in the sphere of rationalization mechanically inherits the soviet approach with its formal attitude to thematic plans ("temniks") on inventive activities. The thematic plans often include only the title of the theme (according to the production area), current state, technical specification, aim of the theme, expected results, and names of consultants. There are the following reasons for that: 1) top management does not understand the importance of production renovation; 2) there is a lack of specialists involved in rationalization at a company; 3) the skills and qualification of the staff in patent office do not meet the requirements; 4) there is a shift in responsibility for plan implementation (the responsibility for production plan performance is greater than that of rationalization plan) etc. According to IP specialists (CNIITMASH) it is the liquidation of patent groups of companies that has recently led to the disastrous state of the invention area in the domestic industry [11]. Currently the Southern Korea produces about 18 thousand inventions annually, which is 4 more than Russia (!). To compensate the lack of specialists involved in rationalization in modern companies, it is necessary to institute "management of rationalization" departments in the leading companies of the country (for example in the workshop of OJSC "NEVZ") [12].

To develop a profound thematic plan (temnik) is a deep intellectual work. Currently, the most advanced temnik inherited from the Soviet past time is the plan developed by Scientific production association "Tzellulozmash". It was created by A.B. Selutzkii as a set of tasks applied to the manual for invention and rationalization "Algorithm for solving inventive tasks" (ASIT) with "Album of main ways to eliminate technical contradictions" [13]. All the 25 topics are presented there in the form of technical contradictions and have a sound informative support (UDC, IPC, etc.), targeted consulting support, and detailed motivation mode (minimal remuneration for invention).

Problem statement and solutions

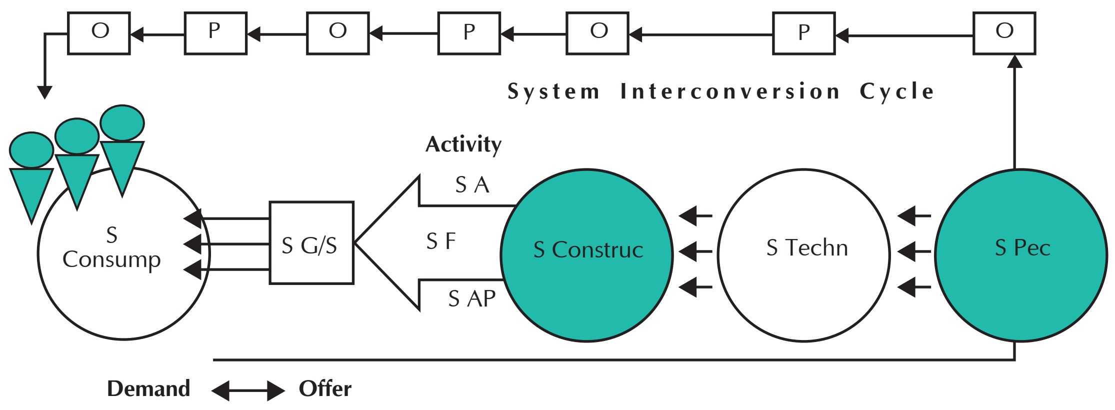
The recent analysis of rating "100 top rationalizations in industry" shows that statements of the required system changes are out of date. They do not meet the realias in terms of the accuracy in determining necessary and sufficient levels of changes in constructions, technologies and materials. It can be proved by the example from OJSC «Production system Rosatom» («PSR») related to complex testing (diagnostics) of the company (CTC) developed on the basis of cooperative work with c McKinsey, knowledge in Toyota Production System, and "Guidelines for complex testing in searching the resources to increase labour efficiency at the enterprises and construction sites of Minsredmash 1962" [14]. The result of the activity is "The Instruction to input CTC database". Several check-lists allow making a list of problems at the company for 4-5 days. The problems are classified then and serve as a base for a calendar plan of production improvements.

It is natural to strive for cost reduction (to save time, money, and labour spent on production changes). It would be perfect to obtain the required changes without any efforts at all. However, the reality proves that we should score twice before we cut once. Thus, it is necessary to know clearly what to be scored for better changes.

We suggest using the notion about the interactions between process and object systems. Fig. 1 schematically shows the cycle of system interconversion aimed at satisfying a complex of customs' needs (S Consump).

In terms of economics it is "Demand". It is satisfied by "Offer", which is made by goods and services (S G/S) produced by the totals of constructions (S Construc.). The latter is the total of material (object) systems.

Fig. 1. Cycle Scheme of interaction between process (P) and object (O) systems, where S Consup, S G/S, S A, S AP, S F, S Construc, S Techn, S Res – totals of needs, goods/services, actions, action principles, functions, constructions, technologies, and resources



Their activity is shown as a stream of total actions (S A) that implements the total of functions(S F) via total of action principles (S AP).

The functions are understood as a content of actions and are placed inside the arrow S A, while the action principles are in the arrow gap, thus opening the ways the actions are implemented.

S Construction, in its turn, is made of the totals of process systems (S techn) and (S resources). All the totals are incorporated in the cycle of system interconversion – object (O) and process (P) ones.

Let us prove the complementarity of opposite actions (A) and functions (F) by the following dialectic scheme. Table 1 shows that different action principles (AP), which are between the actions and functions like between the opposite poles (– and +), constitute a spectrum of forms of relations and links.

Dictionaries traditionally define a principle as the basic property of a device or a mechanism. The search for the principle as the basis for all existing things was the main activity of Greek philosophers. Thales considered it to be water, Anaximenes called it "apeiron", and Anaximander thought it to be "amorthic air". Modern scientists believe that the difference between the notions "principle" and "law" is the issue of terminology.

Based on interrelation between the object and process systems, we offer a procedure of a gradual identification of a desired (necessary or adequate) level of changes in them. The procedure is primarily focused on technical systems; however, it can be applied in managerial systems as well. It is reasonable to rely on a system of test questions that are used in TRIZ engineering [15]. According to them, if a technology is modernized, it is prohibited to change the construction; however, it is necessary to define the rate of restrictions for technology changes. The next stage of changes is the modernization of the construction (device), which does not have restrictions in technology changes; however, it is necessary to identify the restrictions imposed on the construction itself.

Let us present these steps in the matrix form (table 2). The main diagonal is a zone of restriction specification, which is shown in dark color. The grey zone above the diagonal is the zone of prohibited changes. The light zone under the diagonal is the zone of any permissible changes of the system [16].

It is known that an alternative system with the same function as an existing system, but having other action principle (AP), is the

Table 1. Action-function interaction

Action (A) as a phenomenon (–)	Action principle (AP)	Function (F) as an essence (+)
To cut a steel sheet in half with an abrasive disk	Mechanical	To divide a sheet in half
To cut a steel sheet in half with gouging		
To cut a steel sheet in half		
To cut a steel sheet with guillotine		
To perforate a steel sheet in the middle		
To press a piece		
To etch a sheet with acid in the middle	Chemical	
To burn a sheet in the middle	Physical	

most competitive one. The other principle ensures the most functional feedback [17]. In this case we face the replacement of the "old" system with the new one that has resources for a quantum jump of the basic parameters.

A good example of such replacement is plant grafting – the "new system" (scion) is joined to the "old system" (rootstock) to produce stronger and efficient species. The choice of "old system" as a rootstock is reasonable in terms of economy and sociology, since it takes into account the inertness of a human being.

The "old system" is dialectically presents sustainability, while the "new system" is the variability. In this case, we observe a qualitative change.

When alternative systems are united together, it can be compared with injection of "new blood". It is a moment of replacement

Table 2. Degrees of permissible changes in engineering

Levels of changes	Object of changes				
	Techno-logy	Constru-ction	AP	Function	Needs
Modernization of technology			Prohibited changes		
Modernization of construction		Restricted changes			
Reengineering of construction					
Creation of new object	Acceptable changes				
Prognosing					

of old laws, principles and structures with the new and more efficient ones. According to R. Foster, it is a "technology gap" [2] or according to M. Hammer, J. Champy, it is the situation when reengineering is urgent [18].

Thus, the suggested procedures to gradually identify the desired level of changes in constructions and technologies ensure principally new regulations for planning and managing inventive and innovative activities of domestic industry. The topicality of the issue is proved by a great number of current articles devoted to the assessment procedures in the spheres of invention, rationalization and innovation [19–21].

Conclusion

To increase the competitiveness of the domestic production industry, it is necessary for engineers to understand the levels of technological and constructional changes. To identify the action principles of the system is of special importance. The system efficiency can be radically increased only on condition that the newly identified action principles are applied in production renovation. The suggested procedures for gradual identification of the desired level of technology and construction changes are based on the interconversion cycle between the process and object systems, and are aimed at achieving the goals mentioned above.

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UDC 378

Peculiarities of Engineering Education Within the Innovation-Based Economy

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Abstract
In today's fast-changing market, the link between the decisions made in different fields is of significant importance. This peculiarity should be reflected in engineering education. The theory of technological modes serves as a methodological basis for the current research. It has been revealed that engineering-economic environment is shaped as a combination of technological modes, within which the problems of harmonized development of technologies are solved. The models to shape engineering knowledge under modern conditions are proposed.

Key words: innovation, engineering, models, multidisciplinary, technological mode, economy.

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Introduction

An ongoing shift in global economic activity [6, p. 391; 12] (development of innovation-based economy) stipulates the changes in education [7, p. 245; 20]. It is required to consider the link between the changes in engineering knowledge and innovation market.

The thing is that in the modern highly-integrated market technical objects definitely perform their applied (technical) functions. However, they increasingly perform so-called systemic functions, i.e. the functions that affect constructive processes of economic environment.

In practice it means the following. A new integrated circuit is designed. Its introduction into the market stipulates rapid changes. As a result, new conditions for advancing the integrated circuit emerge: new consumers' requirements, technological capabilities, use options. All this advances the integrated circuit and contributes to further change in the market conditions. In this context, the changes of the integrated circuit should not cause the discrepancies in the constructive processes of economic environment. Otherwise, an ongoing advancement of the integrated circuit will cease. Therefore, the integrated circuit should possess systemic characteristics that manage the concurrence of market changes (concurrence of constructive processes).

It is essential to secure the required technical and systemic properties of an engineering object. While designing an education programme, it is reasonable to find the answer to the following question: how a complex of engineering objects ensuing concurrence of changes in technical and economic environment is formed?

For this purpose, it is necessary to examine the processes of modern engineering knowledge acquisition, develop the models of knowledge acquisition and design the corresponding curricula. These issues have been addressed in research literature [1, p. 57; 2, 5, 17]. Precisely, they are examined in the works dedicated to "Knowledge Management" [14, p. 37; 15, p. 46]. However, the fundamental processes of an innovation-based economy have not been considered. To be more precise, the peculiarities of technical and economic knowledge interaction in the innovative development of systems have not been examined.

The peculiar feature of the current study is the use of the innovation-based economy development models. The essence of the applied models is as follows: modern economy is based on the numerous production modes [6, p. 391] developed by mass technologies of different origin (industrial, informative, social, etc.) and forming the corresponding technological modes (S.Yu. Glaz'ev [6, p. 391; 7, p. 245; 8, p. 256]). The technological modes are comprised of highly-integrated complexes of consumers, manufactures, products, etc. (microelectronics, information systems, the internet, mass information systems, mass consumer technologies, etc.). Each mass technology is enhanced alongside the corresponding technological mode. Therefore, a technological mode is often an object of engineering research.

The article examines the processes of knowledge accumulation in technological modes of the innovation-based economy. The design peculiarities of the corresponding curricula are presented. This fact of a great interest as the theory of technological modes serves as a basis for one of the well-known options of the Development Program of the Russian Federation [7, p. 245]. The results of such experiment are not found in research literature.

The article describes the proposed models of engineering knowledge development. They can be applied for design curriculum in microelectronics. The analysis of the course content has revealed that the following tasks are fulfilled: harmonization of mathematical modeling and expert methods, "resonance" of knowledge during the course material delivery, simplification of some course parts, etc.

It is proved that engineering education should incorporate such courses as "Systemic analysis in innovation-based economy" and "Fundamentals of innovation-based economy". The obtained results can be applied in design of courses for the experts in technology development management in the innovation-based economy.

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1. Materials and methods.

1.1 Methodological problem of modern engineering development

Ensuring harmonization of numerous changes stipulated by the constructive processes of different nature is one of the overriding tasks in the modern economy (innovation-based economy). It is required to harmonize all the development processes within the knowledge system [18, p. 28-31]. Therefore, to study engineering industry in the innovation-based economy, it is necessary to define its role in solving this problem.

Harmonized development of technological and economic environments is secured by two types of methods to shape the future [3, p. 75; 4, p. 73]. The first method implies description of knowledge via the formal models (theoretical, logical) followed by the modeling. This method can be primarily applied in natural science. The main property of the formal models is that the so-called "packed" knowledge stipulates properly harmonized constructive processes of different nature. The formal models of Euclidean geometry are the best examples. They created "resonance" in development of numerous sciences and caused fundamental transformation of Ancient Greece thinking. The mechanics of Newton and Leibniz played even a more significant role in integration of sciences. Thus, development of knowledge within the natural science area could not be separated from creative processes originated both in social and economic environments [9, p. 6-10]. This link should not be disconnected in education that is tied to rapidly changing market.

However, in the course of economic-technological environment development (quantitative changes) many formal models lose their adequacy regarding practice. Correspondingly, there is a loss of the link between the models and creative (constructive) processes. The knowledge system loses the link with the economic environment. As a result, there is a falling interest in acquiring formal knowledge (primarily, Mathematics).

The second method to harmonize the development of systems is rooted in the systemic methods [1, p. 57; 3, p. 75; 4, p. 73; 21, p. 352]. The conditions for harmonizing constructive (creative) processes which have been deduced from the gained experience are registered. The relation patterns that secure harmonization of the taken decisions are developed [11, pp. 13-25; 14, p. 1159; 21, p. 352]; concepts; unified values; indicators. They define the conditions at which the forming constructive processes might be harmonized. This increases the validity of the experts' opinions. Such approach is peculiar to the humanitarian sciences. The problem is that the impact of various decision making patterns can be rather controversial, insufficient and unstable. This impedes innovative development that requires high harmonization.

The two above-mentioned methods are closely interconnected. Each method performs its function in harmonizing the development elements and each of them has its own limitations. It is essential to ensure harmonization of the results obtained due to the use of these methods.

In the field of engineering, two methods are applied: formal methods of Physics and engineering, as well as systemic concepts and patterns. In this respect, it is regarded both as a natural science discipline and economic one. Therefore, for engineering development (as well as to design a comprehensive education programme), it is required to ensure continuous harmonization of the results obtained due to application of formal-logical and systemic methods in designing systems. To enhance the efficiency, the methods should complement each other.

Obviously, it is impossible to solve this problem via analytical tricks. The solution could be achieved only by means of new properties of technological and economic environments. It is required to indicate the specific processes that stipulate these properties in the innovation-based economy. Their models would become the bases for mastering engineering disciplines and designing engineering programmes.

The notion "engineering" is primarily referred to the mechanisms of knowledge generation, but not to discipline-related properties.

1.2 The model to shape engineering knowledge that stipulates innovative development

As noted in the introduction, the modern economy is rooted in mass technologies that shape their own technological modes. In the technological modes, the problem of integration and harmonization of development processes is naturally solved.

The harmonized physical, economic and other knowledge advances as the result of the constructive processes of the corresponding technological modes. Therefore, to design adequate education programmes, it is essential to develop the models aimed at enhancing engineering knowledge within the technological modes. They are determined by the peculiarities of modern mass technology development including corresponding technological modes.

The complex mass technology or a tool could be hardly improved as a whole since its changes are secured by a combination of numerous harmonized constructive processes of different origin. Therefore, modern mass technology (including its technological mode), as a rule, advances as a combination of options (table 1) of its industrial units [19, p. 49]. It means that it is required to study simultaneously all the available options.

Each described option (represented by a certain industrial unit) is focused on

Table 1. The elemental cluster

	Segment A	Segment B	Segment C
Industry type	Mass production	Manufacture on the basis of new stable technologies	Innovative production
Consumer type	Traditional	Continuously developing	New
Dominating properties	Harmonization of numerous technological processes, product requirements	Enhancement of the most popular technological options and products	Improved properties within certain new trends
The role in technological mode development	The link with the constructive processes of the "previous" technological stage	Enhancement within the stable trends	Solutions for shaping future technological mode
Dominating methods	Expert methods	Combined	Formal-logical

the enhancement of a set of parameters (table). Precisely, some plants are aimed at increasing the production yield of non-defective products. At the other similar plants, parameters of radiation stability are improved. Obviously, the plants are interconnected as they enhance the same mass technology. It is essential to ensure the unity of the constructive processes stipulated by the changes in the technological units. It can be achieved due to the fact that each of them corresponds to a certain stage of technology enhancement [19, p. 50-59] (table). For example, technological unit A supports the constructive processes tied to the economic environment of the past. Technological unit C contributes to enhancing new generation of technical equipment and machinery. The corresponding plants are characterized by different operation criteria, consumers' properties, and research pattern, etc. (table). Improvement of mass technology as a whole stipulates further enhancement of all technological units (that support different stages of the discussed technology improvement).

This means that to ensure the "resonance" of knowledge associated with these different technological units (physics, engineering, etc.), it is required to study the corresponding subjects as a whole simultaneously and coherently. This actually defines the teaching mode. In addition, it is necessary to ensure harmonization in knowledge development. For this purpose, properties (parameters) of technological units should be also well-balanced and meet some relations. This would determine the disciplines to be included in the education programme.

To define the properties and relations, it is required to elaborate the unified model of innovative development mechanism shaped within the technological mode due to the act of increasing number of mass technologies. It should determine the conditions for solving the problem of harmonization of systemic and formal-logical approaches within the innovation-based economy.

The essence of the model is as follows: to ensure rapid development, there are certain objects in the market whose systemic properties are primarily connected with the

constructive processes of the past; there are also objects whose systemic properties are aimed at stipulating the constructive processes of the present and future (fig.1).

In the innovation-based economy, all constructive processes should constitute one harmonized constructive process, preserve the unity of the past, present and future processes [4, p. 73-75; 10, 11, p. 13-41].

Harmonization should be achieved by emergence of a broad-scale mass technology (fig.1). Definitely, a broad-scale technology affects the constructive processes linked to all objects and, at the same time, removes the barriers that impede enhancement of the constructive processes. The constructive processes that are continuation of the past processes and part of the present and future ones emerge (fig.1). In addition, they are integrated by mass-technology and, therefore, constitute the required unified cross-cutting constructive process of all generations.

In this case, the formal-logical and systemic approaches or methods are properly-harmonized. Obviously, the constructive processes of different generations are connected with a certain formal-logical or expert methods (this will be covered in the next section). The integrating effect of technologies ensures harmonization of their application results.

Therefore, the study aimed at investigating knowledge (course content) that emerges as the result of technology development (fig.1) is of particular interest. It is urgent to address the issue of designing education programme content that would be adequate to market conditions and the system of engineering solutions. For this purpose, it is required to determine the optimal criterion for mechanism operation (fig.1).

A more detailed analysis of this criterion is beyond the scope of the current research. Simply speaking, the essence of the criterion is as follows: in a case of a great number of new solutions, a mistake is likely to occur; in a case of a great number of out-of-date solutions, the development strategy mistake arises; therefore, the amounts of funds of different generations should be balanced [19, p. 49; 21, p. 352]. This actually stipulates the balance of the constructive processes. The balance is defined by the consistency between the fund amounts of different generations [13, 21, p. 352].

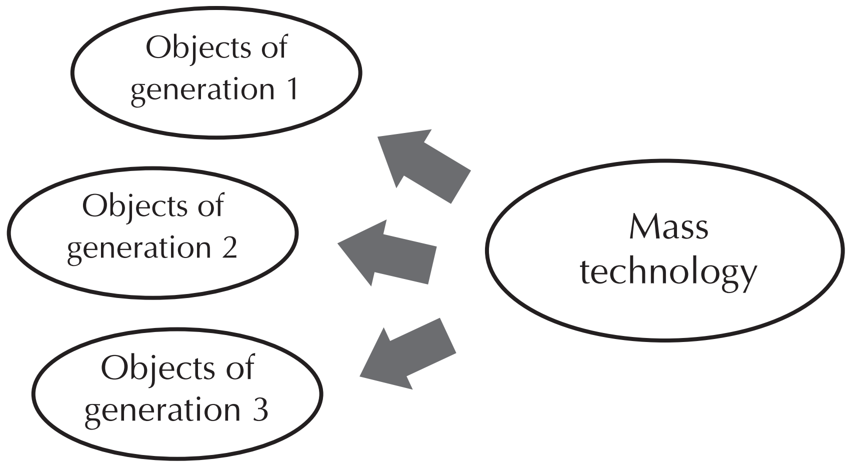
It appears from the foregoing that education programmes should deliver engineering knowledge shaped within the technical and economical environments that correspond to the systemic criterion and the model presented in fig. 1.

2. Results

The content of engineering course

Let us examine the simplified example of course design, which is aimed at studying

Fig. 1. Model of innovation development origin



the integrated circuits of signal processors (integrated knowledge of physics, circuit engineering, architecture, manufacture management, applications).

Formation of technological environment is represented in fig. 2. To adequately solve well-known consumers' tasks on the basis of the optimized mass technologies, the integrated circuits of the purpose-designed processors are developed (segment A, fig.2). They actually reflect the peculiarities of processing algorithms and opportunities to apply the options of mass production (in fig.2, segment A represents the "past" generation). Here, numerous well-harmonized physical effects, engineering solutions, special algorithms and etc. that stipulate "resonance" effect in physics, circuit engineering, and applications are used. The harmonized standards for decision making are defined. The systemic approaches are efficient. This allows using exports' opinions during course delivery, which defines the peculiarities of teaching modes.

However, it becomes even impossible to generalize knowledge interpreted by experts with the increase in difficulty in segment A. Therefore, the course should familiarize students with the mechanism to manage harmonized development of knowledge. In addition, it is necessary to consider the model of future development.

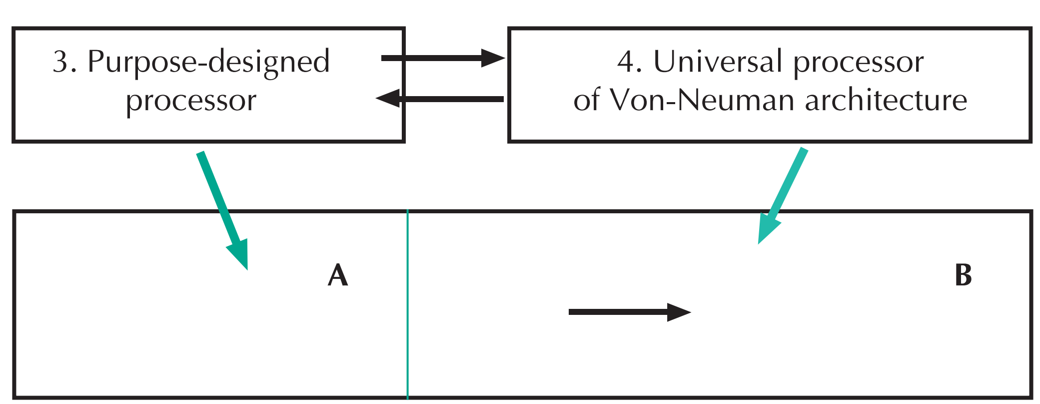
The number of tasks increases (additional segment B appears, fig.2). In this context, the environment of segment A, which is focused on solving early examined problems, could hardly be involved in solving the tasks of segment B. The system may stop developing as it is difficult to build an integrated circuit of additional purpose-designed processor within sufficient experience in solving problems of segment B. Due to this reason, the system should include the integrated circuit of a universal processor which is able to solve the problems of segment B (even for a long time period). As a simplified option, it could be a universal processor of Von-Neuman architecture performing in sequence simple operations and is based on a simple physical structure. This allows designing algorithms for resolving new tasks which do not require absolutely new physico-technical solutions and knowledge of circuit engineering. This fact gives the opportunity to carry out experiments in physics and circuit engineering on the basis of well-examined problems, thus, increasing the system quality. Therefore, segment B is a study of "the future" stage in development of technical and economic environment.

The main peculiarity of this segment is that similar technical solutions, operations and algorithms are united. Therefore, segment B represents the area of formal-logical modeling. This defines the specific ways to master the knowledge related to this segment.

3. Discussion

Thus, a set of processors includes segment B which serves as a tool to study the

Fig. 2. Model of harmonized expansion of signal processor technological mode



"future". There is also segment A that shapes the harmonized knowledge (incorporates "the past" into the system development). Segment A mostly applies systemic methods and approaches. The Formal-logical methods are peculiar to segment B.

Therefore, the proposed course explains physics, engineering, and mathematics regarding two separated, but interconnected market segments of integrated circuits. It means that two harmonized sets of knowledge that create required conditions for each other are studied. This allows studying different segments via different methods, apply different criteria for learning material selection. For example, to evaluate the quality of segment A, it is possible to apply experts' estimates, while segment B requires using Moore's law [16, p. 384]. As a result, the problem of studying knowledge related to different areas becomes less difficult.

However, it is always required to secure harmonization of the studied segment properties. To solve the problem of on-going integration, it is essential to apply systemic analysis.

It is worth noting that the main task of the systemic analysis is to ensure harmonization of numerous solutions (constructive processes and objects). Within the innovation-based economy, this task is naturally resolved. It means that the instrumental environment of this type of economy becomes the basic object of the systemic analysis.

The systemic analysis is a part of both natural science and economics since it considers physical properties of an object in conjunction with the constructive processes (cognitive processes). This actually posed the challenges in its development. The innovation-based economy eliminates these challenges. The systemic analysis becomes a well-organized discipline as formal-logical and systemic approaches are harmonized (simplified). It allows solving the problem of optimizing the process of shaping instrumental environment and engineering knowledge. Therefore, an engineering course should be always supplemented by the discipline "Systemic analysis in the innovation-based economy". In addition, it is also useful to introduce the discipline "Fundamentals of the innovation-based economy" that examines the certain examples of new engineering impact on transformation of economic, social, and other relations.

Conclusion

The transition to a new global technological mode changes the model of economy enhancement. It is the most important innovation and resource. As a result, engineering knowledge that includes both systemic (economic) and technical aspects appears. Such knowledge is shaped at technical and economic organizations that function in accordance with the peculiar models of the innovation-based economy.

The development of the innovation-based economy stipulates "revolution" in the systemic analysis. As a result, there arises the basis for analytical management of engineering knowledge development. It should be included in education programmes.

Master's degree programmes offered by universities should provide students with that knowledge that is interconnected by the models of enhancing technological modes of various fields. As a result, the teaching process becomes simpler. In addition, it becomes easier to harmonize and revise the elements of education programmes, which, in its turn, assists in connecting theoretical engineering knowledge and applied tasks and problems offered by a new economy market.

The obtained results have revealed the peculiarities of engineering education intended for high-tech business within the innovation-based economy.

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Development of Engineering Creativity in the System of Specialists' Training

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Abstract
The article discloses the issue of developing engineering creativity as an element of the qualified specialists' training. The researched forms and methods of organizing engineering creativity in Russia are analyzed in comparison with these activities in foreign countries. The author shares his experience in organization of classes aimed at development of creative abilities of students and provides the achieved results. The proposed conclusions underline an opportunity for transferring best practices to the practical activity of other educational institutions.

Key words: engineering creativity, simulation, design, self-improvement, social partnership, creative abilities.

"One involves in creative activity not at the age of 15-20, but when he/she is four..."

Modern society that is developing based on the accelerated progress ought to solve new tasks. Scientific and technological development requires creation of unique, exquisite technology, design and mechanisms in any field of economy, provided full-manned qualified staff, which possesses both skills of using advanced technical equipment and ability to develop creative skills.

A topical issue is the formation of future specialists able to solve tasks aimed at innovative development of production industry and at formation of deliberate professional choice for personal development. Possible solutions for developing engineering creativity are researched as elements of the system for training qualified specialists.

In the context of modern conditions the basis for innovative activities is the scientific and technical creativity. Mastering skills of engineering creativity implies development of ability to create new technical means, generation of modern and demanded innovative ideas, shaping them to their logical end, preparation of project documentation, experimental development prototypes, and serial production. Formation of an accomplished personality with the required level of education turns to become one of the most important tasks in future specialists' training at an HEI, becomes an essential part of the modern system of training. Development of scientific and technical creativity skills gives students, aiming to master a certain profession, an opportunity to enhance professional and social proactiveness, which, in its turn, is realized in deliberate professional self-identification, increased level of productiveness, progress in improving scientific and technical potential of the production.

The main aim of training young specialists the basics of engineering creativity can be seen as raising interest and, later on, forming and developing a system for fostering creative attitude towards professional activity, which would lead to fostering skills of scientific research work, to finding the need for rationalization and innovation in their professions.

The process of formation and development of students' interest in technology and engineering creativity allows fostering their engineering thinking, spatial imagination, observation, visual and motor memory, technical proactiveness and skills. These features are necessary for understanding systems of constructional and technological requirements of the industry.

Researchers B.P. Esipov, V.A. Sukhomlinskyi, G.I. Bukina formed the main requirements for training creativity to youth, which is an essential component of personality development. Issues that come along the process of forming and developing engineering creativity skills of students have been analyzed in a number of studies by P.N. Andrianov, V.E. Alekseev, G.S. Altshuller, V.A. Gorskyi, S.K. Nikulin and many other scientists and practitioners. Educators I.P. Volkov and V.F. Shatalov showed on practice a convincing opportunity to turn the theory into everyday practical activity of students. However the process of developing students' disposition towards engineering creativity is a complex, multifaceted and multidimensional activity [1].

Development of the system for engineering creativity within specialists' training requires development of the system of education, integration of vocational, general and professional education into a comprehensive complex. Formation of students' abilities in engineering creativity requires implementation of certain technologies, specific for training teams consisting of mixed-age students. Particular attention to the methods of forming engineering creativity skills of students from various specialties has been paid by such scientists and practitioners as M.M. Zynovkina, A.E. Larin, V.V. Popov and others [1].

Besides the achieved positive results, the issue of training engineering creativity as an efficient instrument for improving the quality of education requires conduction of further research. Insufficient elaboration of theoretical and methodological foundations obstructs wide implementation of new methods for training engineering creativity at HEIs. It is essential to create a system to integrate the whole community of educational institutions, including preschool institutions.

Young kids are attracted by an opportunity to get involved in children's engineering creativity. A chance for creating a craft independently and for presenting it to relatives or friends is just a small visible tip of an iceberg of engineering creativity. The very first craft created by a child gives an understanding of his/her creative independence and an aspiration for cognition of the surrounding world by means of this craft. Creating any crafts, models sets requirements towards gaining knowledge in various scientific and technological areas. By creating any piece of work an author discovers his/her own strive for new knowledge and innovative character, which become the main features of the future creator. Youth show their interest in creative activity more distinctively than adults. Granted the encouragement from adults, they develop a constant need for creative activity, which results in their striving for self-improvement [4].

Many countries put great efforts for developing children's engineering creativity. Organization and development of engineering creativity in France, Germany, England, Finland, and USA is executed in a private manner. This creativity mostly has sports and technical trends. T.G. Kazakova [5] discloses the position of USA researchers, who dedicated their activity to learning issues of children's creativity. Scientists V. Lounfelda, U. Lambert give the main influential role to the new subjects that provide the environment for forming emotions and creative and logical thinking [2, 3, 10]. Russian and Soviet pedagogues, who devoted their research to children's engineering creativity, base their research on the theory proposed by such scientists as V.A. Gorskyi [6], V.N. Varaksin [7], and many others. Thus, V.A. Gorskyi considers common problems that exist in the methodology of engineering training in general schools. In his works he underlines the specifics of system formation for engineering creativity training, uncovers logics of technical creation of models and devices, and describes main stages of education.

Implementation of the proposed forms and methods helps teachers to foster students' passion for engineering creativity, their self-identification.

The Education Development Federal Targeted Programme for 2016-2020 [8] approved by Directive No. 2765-r of December 29, 2014, issued by the Government of the Russian Federation, enacted the Concept for modernization of education [9]. The programme emphasizes a unique role of professional education in the development of dispositions and abilities, as well as professional self-identification of youth. Focus on creative activity in professional education is recognized as the basis for training young specialists. Students find interest in their work results. They develop a need for creative search, for application of the whole potential of an HEI available for students. The aspiration for finding ways for improvement and self-improvement increases. At the same time, by getting acquainted with the basics of engineering and scientific creativity, students foster their creative attitude towards the process and develop deliberate understanding of their activity, which encourages future specialists' professional development.

Based on the example of a number of professional educational institutions, such as Novosibirsk College for Car Service and Road Industry, Novosibirsk Industrial and Energy College, Berdsk Polytechnic College, Novosibirsk Radio Engineering College, activity of pedagogical teams, aimed at solving the issues of engineering creativity development as an element of training system for qualified specialists, can be noted. With an aim to increase students' motivation towards studying elements of creativity a number of creative projects is executed. Teachers conduct workshop on automotive services, creation of light motor vehicles, automotive model design, aeromodelling, design of radio communicating devices and other. In the past years, professional educational institutions organize recreation day-camps for increasing children's motivation for engineering creative activities.

A system for industry-specific education is created. When a student sees that a model of a real machine unit of a car can be created in 45 minutes, when his/her classmate rides a vehicle created on the basis of a typical jig-saw, the prospect of his/her attraction to creative activities increases multiply.

In spite of complex and, typically, dependent on external influence economic problems existing in Russia and its regions, material and equipment support of professional educational institutions strengthens.

Teams of regional HEIs, when researching the topic "Development of engineering creativity as an element of qualified specialists' training system", have analyzed possible problems that significantly influence the formation of an efficient educational model for training engineering creativity skills that effect qualified specialists' training. Out of a number of problems the following ones have been underlined as the most significant ones for HEIs:

- Prevalence of individual situational problems over the problems of professional education organization as a whole, continuity of its contents, development of required competences within the individual work plans.
- Inefficient arrangement of solving problems concerning educational quality improvement, based on the need for improvement of teachers' qualification level; lack of pedagogic community differentiation according to their level of motivation for studying.

Distinctness of the requirement proposed by authors to construct a structured scheme of the system for engineering creativity training lieы at the root of the importance of the following features:

- Novelty and uniqueness of the contextual matter of the methodological work, of the methods for strengthening the importance of advanced professional activity of teachers.
- Need for organization of research, scientific and methodological components of teachers' work in teams, when developing and executing educational, methodological, research and scientific projects.
- Efficient creative activity within the laboratories (in line with WS standards), interregional specialized competence centers (WSR-Siberia) created in colleges.
- Participation in professional management of educational institutions' project activity.
- Participation in Priority National Project "Education".
- Participation in the work of experimental platforms created in educational institutions.
- Assessment of pedagogical work efficiency based on its final result.
- Formation of new, in-demand competences of teachers as a basis for their professional mastership.
- Expansion of the range of questions for development of creativity that promotes continuous advanced education of teachers.

In the framework of creating a system for pedagogical team's activity, the following milestone ideas have been identified:

- Motivation of pedagogic staff for studying professional management of educational institution's project activity.
- Motivation of pedagogic staff for their successfulness.
- Informational presentation of the positive results of particular teachers.
- Long-term prospective planning of key achievements.
- Monitoring of educational services' quality, which is based on analytical, directive and diagnostic principles.
- Organization of optimum forms of interaction between educational institutions in the framework of network communication and the created educational cluster.

The importance of the chosen development route of an educational institution's scientific and methodological work lies at the root of training specialists with modern level of thinking able to realize his/her creative potential.

The result of such training positively affects students' academic progress, which is proved by their achievements at regional and all-Russian competitions. Thus, Novosibirsk College for Car Service and Road Industry student won the 1st prize on a regional competition for "Automotive Mechanic" profession. Another student won the 1st prize in the selection round of WorldSkills Russia (Siberian Federal Region) in 2015. Another student of the college won 2nd prize on the III National WorldSkills Championship in 2015 in Kazan.

Among other achievements, college students:

- won the Finals of the Siberian Federal Region Championship on work professional according to the WorldSkills Russia standards, that was held on the premises of the International ExpoCenter "Siberia", based in the administrative business center of Krasnoyarsk on March 23-27, 2016;
- were among awardees of the 11th Regional Students Olympiad on professional education (Novosibirsk);
- participated in International Conference "Policy and Educational Development in a Global Context" organized by the Comparative Education Society of Hong Kong (CESHK) in the University of Hong Kong in March 2014;
- won All-Russian Competition "Engineer of the Year, 2014" in Moscow, February 2014;
- were among awardees of the Annual Regional Review Competition "Master of the Year";
- were among awardees of the All-Russian Competition of scientific and technical creative works of students studying at vocational programs, 2014-2015.

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For the further realization of the engineering creativity training system the authors propose:

- to enlarge the network of locational platforms;
- open platforms for interaction with social partners and industrial enterprises;
- conduct expert assessment of the quality and efficiency of the realization of extracurricular educational programs for children in the capstone educational institutions;
- conduct regional competitions on robotics and children's innovative engineering creativity with attraction of engineering staff of the interested industrial enterprises;
- provide training and send delegations of students of the regional educational institutions for participation in events for gifted children on Russian and international levels.

The main aim of solving problems for the development of engineering creativity as an efficient instrument for improving professional mastership of students is the task for creating conditions for maximum self-expression of students [7].

Declaring the fact that the country needs trained workforce is unsound unless a sustainable interest for engineering creativity is expressed. For that, it is necessary to create a specific comprehensive educational system and to advertise widely the attraction of children and teenagers to youth's engineering creativity. It is the engineering creativity of children and teenagers that is the basis, the required foundation for training of qualified specialists.

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The Problem of Value-Based Guideline Formation for Future Professional Activity

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Abstract

Contemporary education is aimed at training engineers capable of transforming the environment.

Formation of value-based and responsible attitude of future engineers to the environment as a basis of accession into culture taking into account personal qualities and specific living conditions, involvement in innovative activity is a condition and prerequisite for their professional mobility.

Key words: social responsibility, professionalism, professional mobility, innovative activity, integration.

The long-term program of social-economic development of the Russian Federation till 2020 launched the transition of national economy to innovation development [1, p. 57]. Russia still refers to the countries of innovative simulation type, for which the following indicators are typical: low share of GDP innovative component; 2-3 times lower productivity as compared with developed countries, and low innovative activity of state, business, science, and education.

The problem of global competitiveness of national economy has become increasingly relevant. Its solution is impossible without development of human capital, formation of new generation of experts having professional mobility skills, professional competencies, and value-based guidelines in professional activity.

A wide range of engineering university graduates' competencies includes cross-cultural competencies, which, penetrating into all spheres of professional activity, have become a foundation for professional mobility of future specialists.

The comparative analysis of competencies in elite engineering training of Germany, China, the USA, Sweden, Japan allows for conclusion that most part of the competencies (up to 65%) is not associated with engineering sphere, but related to economic, ecological, social-cultural and communicative spheres. This is no accident as contemporary civilization requires new generation of specialists having high level of general and professional culture, innovative way of thinking, as well as moral awareness. In this context the history of small country Singapore is rather exemplary as it is not a resource-rich country, but could make an economic leap forward due to innovative policy. Lack of resources was compensated by intellect, inventory and discipline potentials [2, p. 7].

Engineering training is focused on ability to be a participator in taking all responsible social-professional decisions considering not only personal interests but also social ones. However, the declared priorities are not reflected in engineering training. A negative impact of some factors (careerism, consumer attitude to life, worldliness etc.) results in students' confusion eliminating socially relevant priorities in this way.

Formation of future engineers' value-based and responsible attitude towards environment is a condition and prerequisite for their professional mobility, as it is a basis for accession into culture taking into account personal qualities and specific living conditions, involvement in innovative activity.

In the area of engineering training there is a large number of challenges.

A student receives a diploma in engineering, but works as a manager. It may indicate the fact that a profession acquired by a student can be of diverse scope, but can evidence a graduate's professional non-availability for professional responsibilities, low level of professional competence, and wrong choice of profession.

In our opinion, this fact indicates professional social responsibility performing a principle function of professionalization, enabling "successful solution of professional problems" [3].

Reflexion is a means of regulation of normative-value basis of a job. If different types of human activity are regulated by particular moral norms, profession is also characterized by a mission connected with a purpose [4, p.14]. Professional mobility of a future engineer is to be included in professional ideology.

It was M. Veber [5] who underlined the significance of individual behavior, his/her values in the concept of professional mission. He focused on "reflexive content of professional activity" including selection of profession, its value etc. Whereas R.M. Povalko [6] suggested indicators of "a true professional" that characterize a specialist: professional competence is consistent with social values, whereas a professional him/herself is only focused on societal service. Professionals follow ethic code, whereas for professional community a criterion of professional identity is of significance.

Professions, in A. Flexner's opinion [7], differ from other types of activity. He offered distinguishing criteria: profession is supported by altruism, professionals understand that they work for public welfare. Self-regulation is a sufficient feature of a profession. At the same time, self-regulation is a result of understanding the professional responsibility towards society. However, responsibility can be adaptive (need for conform, respond) and non-adaptive (advance action).

According to D. Bell [8], the concept of professionalism includes not only engineering competencies and status, but also moral imperatives. It is explained by the fact that any job is supported by the norms of social responsibility. It does not mean that professionals are idealistic, generous people. The matter is that "expected model of their behavior, as compared to other people, is predetermined by the ethics of their job which is, as a rule, primary in relation to the egoism ethics".

Started by M. Veber and supported by R. Merton [9], the tradition of research in profession nature has shown the difference of a "true" professional from a partial one. As a rule, the boundary is formed by motivation of their activity, as in "true" professional's activity selfless disinterest prevails in the behavior that is embodied in commitment and professional calling.

M. Veber highlighted that there is an internal cohesion of calling in Life and self-determination in Profession. For a true professional the motifs of professional ambition not related to vanity are of positive significance. In this case, true professional draws the sense of his activity from passion for profession, he/she is "obsessed" with commitment and adherence to a cause.

An indicator of passion for profession is successful promotion towards pinnacle of career. The responsibility focuses on efficiency of profession activity. A good-natured motif of professional is to achieve success in the job and to commit for the cause. Here we have a unity of recognition (status, external approval) and mission (internal calling).

Professional voluntarily assumes the responsibility, as he/she wants to change not only the world, but also him/herself. Development of him/herself is a pre-condition for moral activity. As an example one can take an activity of a modern businessman. The businessman "takes care of his business!". People of entrepreneurial nature prefer, as a rule, to serve the cause.

To be successful in service, one needs to mobilize, first of all,

moral-business qualities of a person. Whereas for self-fulfillment it is necessary to engage the entire person, as self-fulfillment leads to a person's self-improvement, and transcendence, places him/her in a position of criticizing him/herself, involves in the most complicated among all existing and possible arts – creation of him/herself, achievement of success.

At his time L.N. Gumilev spoke about the fact that in any ethnos there is a definite number of people who are characterized by "irreversible inner strive for extremely intense targeted activity always connected with transformation of environment" [10, p. 120]. Using the Latin term passio, he called this group passionarians. In Gumilev's opinion, there are three types in every ethnos: passionarians are people focused on transforming activity, it is an energy synthesis – energy of passion, vanity, achievements, etc.; the second group of people are "carriers of very small share of passionarity that is balanced with self-preservation instinct, which creates harmony of psychic structure (social harmony); the third group includes sub- passionarians who do not change or keep the world, but depend on it, they cannot set goals for him/herself or self-organize…" [10, p. 122].

A person focused on continuous achievements is interested in, first of all, high performance, finding optimal ways, high results with insignificant efforts etc. Therefore, it was noted that the word combination "to make an effect" means to show activity, but not just to demonstrate affects.

In practice, the meaning of the word "success" often does not differ from that of "luck". In V. Dahl's Explanatory Dictionary [86], the meaning of the word is given as: "To manage, to have success, luck, to achieve a goal... To be in time to a place, to make or to arrive in time ... Successful affair, with success, succeeded. ... a successful man is a lucky worker whose work goes with a swing". It is hard to draw a conclusion from this definition whether a man achieves success by his/her own efforts or does it due to favorable circumstances.

An important indicator of a successful person's image is an established person (according to Dahl, "to succeed, come true, be realized, happen"). The same epithet characterizes a successful professional due to his/her achievements. The goal of achievement can be either self-education or self-development, complete self-fulfillment.

In M. Veber's opinion, there are three "images of the world" and three ways to respond to this world that pre-determine the orientation of a person's entire life, trends in his/her social ambitions and efforts.

Thus, the first way was determined by M. Veber as "an attachment" to the world, adaptation to it, the second way is "avoidance" of the world, escape from it, and the third one is "appropriation" of the world, taking possession of it.

However, focus on success, in M. Veber's opinion, is only possible in the framework of the third "world view", i.e. active orientation that encourages acting "in the world" (according to Veber, "worldly austerity"). In essence, it is referred to human transforming activity.

A person as a member of community is eager to communicate. But, at the same time, the nature makes a person escape from community as an individual. The most critical challenge of a contemporary man is to find his/her community, act within it without his/her individuality, that is to keep his/her social-cultural identity. A student's awareness of him/herself as a part of community changes his/her perception of social-professional environment.

As the humanity is transferring to a new stage of its development – the stage of innovative society and knowledge economy, every person is required to demonstrate such "innovative qualities" as demand for something new that would be connected with developed critical thinking; communicative activity, internal locus of control, entrepreneurship, and strive for justified risk.

We agree with the idea of N.I. Naumkin [11] that for an engineer to become a true professional, he/she needs to extend the space of knowledge to the space of activity and life purpose.

However, it is possible to achieve only if, as early as being students, they are taught innovative activity. In J. Dixon's opinion [12], the key professional quality necessary for an engineer is inventiveness which is not even mentioned in FSES of higher education. It is inventiveness that enables generation of new ideas, extraordinary approach to solution of complicated problems which are the beginning of innovative process. In this case one should understand that specificity of engineering activity consists in the fact that it cannot be completely algorithmized, as it has a creative character.

The project of the Strategy of Innovative Development of the Russian Federation for the period till 2020 "Innovative Russia – 2020" [13] provides a more concise definition of an innovative person. For example, an innovative person is a person capable of adapting to changes in his/her life, economy, science, and technology; being an originator of all changes. The main thing distinguishing him/her is the focus on continuous knowledge updating.

As modern information society is a society where a large volume of information is necessary to perform work efficiently, a condition for competitiveness is a shift from acquired knowledge, skills and abilities towards search for missing information and generation of new original ideas. Willingness of innovation is a principle quality of a person. However, it should be noted that it does not still guarantee creative activity. Of great importance is not only the level of specialists' education, but also the level of their professionalism and creative activity.

The paradigm of thinking is changing towards development of project-oriented conscious allowing for constant review of current competencies and navigation in changing situations. A specialist received traditional education is not competitive in this case, as the latter does not keep pace with contemporary technologies.

Hence, according to HE FSES, a graduate of engineering university has to perform the following types of activity at manufacturing site: project-design, production-technological, managerial, research etc. (activity types depend on the profile of training), in this way extending and deepening the future engineer's activity area.

It is the requirement for high level of specialists' training, formation of life guidelines conditioned by the key functions of a modern engineer that define his/her competitiveness, which is a result of his/her professional mobility. Such a specialist could be a support for modern society – society of professionals.

The results of applicants' poll (future engineers) of universities (Tyumen State University, Industrial University of Tyumen) have shown that 70% of respondents believe that education will give them an opportunity to find a highly paid job; whereas more than 80% of respondents are sure that higher education guarantees future career.

As is seen, contemporary youth understands the importance of quality education, but it is not focused on education as a value, essence of human activity. Most often them treat education as a service.

Considering such a phenomenon as "prestige of profession", many scholars have made a conclusion that interest in this or that profession changes in public consciousness depending on labour market demands. In its turn, "prestige of profession" provides either attractiveness or unattractiveness of engineering universities.

Recently, the interest of youth in engineering professions has decreased. To train more highly qualified engineers in the nearest future, it is necessary to revive scientific schools created over decades, but destructed in no time.

Development of a future engineer's personality is a multi-stage process of joining culture and society that promote his/

her socialization and self-fulfillment. In the course of cultural value acquisition a person realizes his/her creative capacities.

It is not a coincidence that current social-economic situation in the country has offered insights into the structure of higher education. There appears a question of updating the integrative approach in engineering education. Integration, in its turn, is impeded by the lack of methodological approaches towards the process; integration of science, education, and innovation; lack of joint production-research projects; poor cooperation with industry and enterprises.

Considering the issue of contemporary education, many scholars note that its purpose is changing. It has become an attribute of general culture. The proof for it is the fact of inclusion of cross-cultural disciplines in some engineering curricula.

Improvement of engineering education is associated with the concept of harmonizing human relations with environment. It results not only in review of engineering education content in terms of improving its humanization, but also transformation of methods and forms of teaching aimed at students' involvement in research and project activities that enable development of qualities providing more competitive position in the modern labour market.

The address to the issues of professional activity, modelling makes us pay attention to S.L. Rubinshtein's research [14] in two ways of life. He distinguished two models, namely, a model of adaptive behavior aimed at development of a person's ability to "fit in" the reality focused on external changes and a model of professional development aimed at acquiring skills to "move beyond" the limits of everyday practice and constructively solve the problems taking into account current changes.

Based on the logic of adaptive behavior model, the education content was updated by means of introducing new disciplines. In this case the peculiarities of students' future professional activity were not considered. Speaking of professional training based on the development model, one should apply the term "professional competence", as competence is always developed in the context of future professional activity.

Ability to design one's professional development gives students opportunity to show mobility, social activity, initiative, independence, and, in this way, respond to social procurement. In these conditions the requirements for a teacher's professional responsibilities have changed including his/her communicative and physiological-pedagogic competencies.

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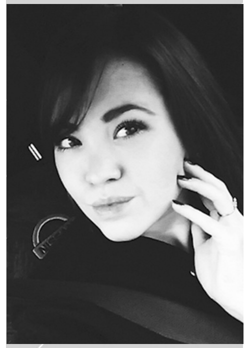
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UDC 378

Implementing Worldwide CDIO Initiative at Siberian Federal University: Heat Power Engineering Programme

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Abstract
The paper describes the experience and results of implementing the Standards of the CDIO Initiative into the Bachelor's degree programme in heat power engineering provided by Siberian Federal University.

Key words: engineering education, project-based learning, CDIO Initiative, heat power engineering.

Enhanced technologies and complicated technological systems, which play a crucial role in economic and social progress, have made the quality of engineering education a particularly urgent issue. The major challenge is incoherence of requirements set by the stakeholders (representatives of manufacturing and business (the prospective employer), the authorities, parents and students) and the quality of education in the sphere of technics and technology. There are several well-known reasons for this incoherence, and they are of both objective and subjective kinds. In other words, these are global challenges faced by universities and science and education communities today [1].

An efficient response to the above mentioned challenges is the CDIO Initiative CDIO (Conceive – Design – Implement – Operate) suggested more than 10 years ago by the academic staff of Massachusetts Institute of Technology, one of the world's leading institutions providing higher engineering education. The initiative implementation aims at meeting the requirement set by the employers to the quality of education and implies modification of education programme, curricula, and learning technologies. All this is supposed to ensure that students develop the competencies, which will dramatically shorten the period of adaptation at the work place [2]. Over the past 10 years, CDIO educational framework has been adopted by more than 115 universities in Europe, North and Latin Americas, Asia, Australia, New Zeland, and Africa. In Russia, the most successful CDIO Initiative collaborators are National Research Tomsk Polytechnic University, Ural Federal University, Skolkovo Institute of Science and Technology, Moscow Polytechnic University, Moscow Aviation Institute (National Research University, MAI), National Research Nuclear University "MEPHI", Moscow Institute of Physics and Technology (State University), etc.

Implementing the CDIO Initiative into engineering education implies changing the approach to education programme design and delivery, in particular [3]: sticking to the CDIO Initiative throughout the whole period of study; detailed description of personal, interpersonal, and professional competencies approved by all programme participants; the curriculum which among other things develops competencies essential to create products and systems and includes the introductory course in product and system design; involving students in at least two projects on designing a product at different levels; creating learning environment which simulates working environment of design organizations; ensuring "integrated" education (learning and work обучение, реальная работа); practice-oriented classes; involving teachers in continuing professional development focused on CDIO; design and implementation of the assessment system adequate to monitor not only acquisition of knowledge, but also development of the ability to create new products and systems; evaluation of the education programme and tools by all stakeholders.

Although the CDIO Initiative is highly estimated and widely applied in numerous universities worldwide, its integration into a particular education programme is still an urgent issue. For instance, integrating the CDIO Initiative into Bachelor's degree programme in heat power engineering implies resolving a number of theoretical and practical tasks. The present article describes the experience and interim results of implementing CDIO standards into education of heat power engineering students at the department of Thermal Power Plants, Siberian Federal University. In 2014, Siberian Federal University was included into the official list of universities implementing CDIO worldwide, and has thus far adapted the Initiative for six.

The key point to ensure the efficiency of the education program based on CDIO standards is the system of individual and group projects (including graduation thesis). These projects secure that student develop personal, interpersonal and professional competencies, which allow creating and implementing new products and systems. The adequate aims, tasks and content of projects not only enhance the curriculum and syllabus design, but also provide new education outcomes, such as: critical thinking and the ability to solve unstructured problems, logical and systems thinking, project thinking (engineering), communicativeness and collaboration, highly developed imagination, creativity, and leadership, global thinking, proactive attitude towards learning (of both students and professional communities).

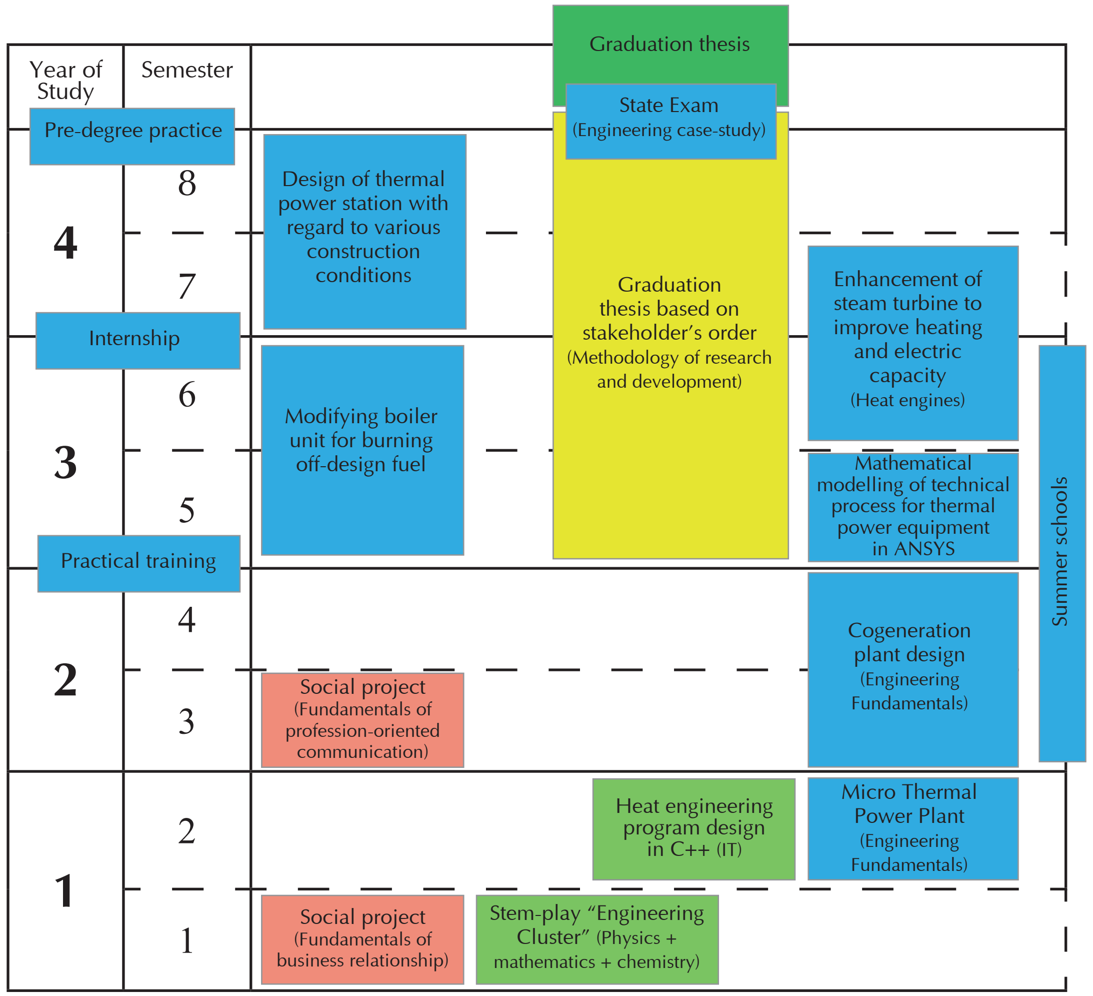
Within the first year of study students are involved into four projects. In the first semester, these are stem-play "Engineering Cluster" and social team project. The number of students in teams varies from 3 to 5. "Engineering Cluster" (designed by Moscow Polytechnic University) is a play tournament, and the task is to organize a manufacturing engineering company, which deals with design of high-tech products. The first stage implies the design of the product in virtual environment, while the second one is face-to-face work and production of the previously designed product. Creation of new products makes it necessary to resolve interdisciplinary tasks in mathematics, physics, chemistry, IT, and perspective geometry. The funding for each order is limited (fig. 1).

Social projects are developed within the scope of such disciplines as "Fundamentals of Business Relationship" and "Fundamentals of Profession-oriented Communication", in the first and second years of study, respectively. The social projects aim at developing personal and interpersonal skills. It is noteworthy that the social projects suggested to students are focused on social challenges faced by different stakeholders, in particular, the graduating department (projects on occupational guidance for schoolchildren), the university (holding adaptational, creative, and sport events), the employer (organizing and holding event on introduction into professional community, as well as volunteer work with Youth Councils of energy companies)

The final project of the first study year (Bachelor's degree programme in heat power engineering) is an individual engineering project "Micro Thermal Power Plant". Within this project, the first year student works step-by-step with the mini thermal power plant, which follows Rankine cycle: calculation and 3D design, component manufacturing and equipment installation, testing and adjusting (fig. 2).

This project allows resolving a number of methodological and professional tasks: students learn how chemical energy of fossil fuel (natural gas) is converted into electrical

Fig. 1. System of educational projects for Bachelor's degree programme in heat power engineering based on CDIO standards

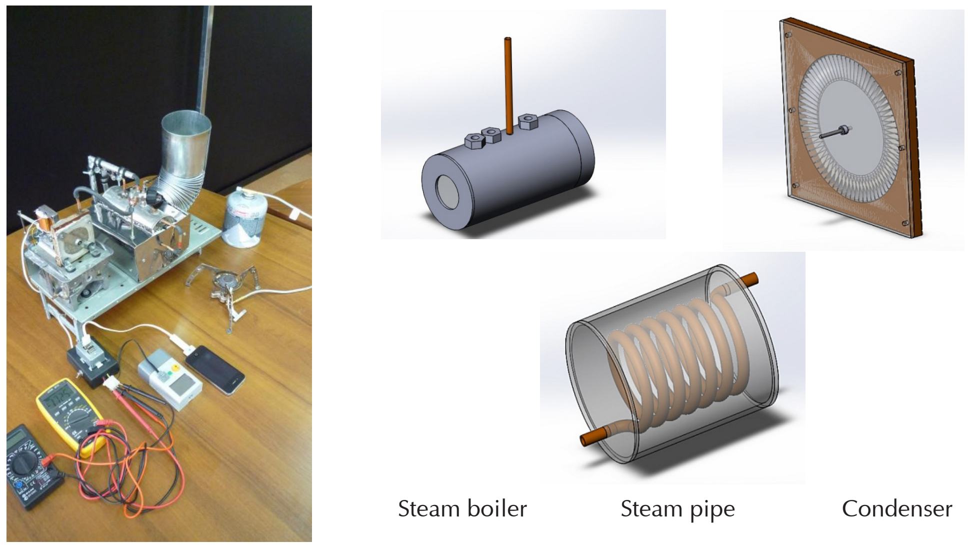


energy; thermophysical properties of water and steam, the principle of Rankine cycle, and heat losses in a generating plant; simplified method of heat calculation for a steam-power workshop and its essential components; design principles and methods to design the components of a boiler, steam turbine, electric power generator, and condenser. It is important to note that the power plant component design integrates such disciplines as "IT" and "Engineering Graphics".

As mentioned above, students work on their projects throughout the second semester, and present the results in the form of competition, in which each participant demonstrates the plant performance and capacity. The results are ranked on the basis of the plant capacity, and the student's final mark for the project strongly depends on his/her rating position (the other criteria taken into account are reliability of design specifications and estimates, the plant configuration and originality, the way the student answers the questions asked by the committee of experts (fig. 3).

Over the second year of study, students carry out team projects aimed at designing various generating plants (thermal and electrical power, including cogeneration and trigeneration). This task allows combining

Fig. 2. Engineering Sample "Micro Thermal Power Plant"



the elements of proactive training with the knowledge acquired within natural sciences and different special disciplines: Engineering Fundamentals, IT, Engineering and Computer-generated Graphics, Physics, Mathematics, Mechanics, Thermodynamics, Heat and Mass Transfer, Fluid Dynamics. The basic options in generating plant design are as follows: plants based on Rankine cycle with various combinations of heat engines (Cyclone Engine, Waste Heat Engine, steam expansion joint, steam turbine rotor (rotor and blade) assembly, Scroll-expander turbine) and heat-transfer agents (the Organic Rankine Cycle); various combinations of conventional and renewable energy sources (wind-solar-diesel plants, heat pumps, solid fossil fuel gas-generating plants), and other hybrid versions. Project implementation includes the following steps: the analysis of technical design specifications, technical and economic comparative analysis of several alternatives, common stages of engineering design (pilot project, draft design, engineering project plan, engineering documentation (in a simplified form)), estimation of specific energy consumption and production cost, design and estimate documentation. The examples of implemented projects are given in fig. 4.

Within the scope of project-based learning, the role and content of practical training and internship undergo significant changes. Students not only acquire knowledge on company structure, major and service equipment, process flow design at the energy company, but also have to search for a project idea, which can be further transformed into graduation thesis. Hence, the majority of students start working on their graduation thesis in the third year of study and are actually involved into this work over two years.

The topic of the graduation thesis can be borrowed from the second year projects (if the project is of high commercial potential), or suggested by the department on the basis of conducted research (in this case, the department is also a stakeholder), or formulated by the energy company and include new plant design, enhancement and reengineering of heat and power equipment. The graduation thesis can be done within the scope of a particular discipline or integrate adjacent subjects. The curricula of the third and forth years of study include the discipline "Methodology of research and development" (6 academic hours a week), as well as the so called "project day", when students have an opportunity to develop an applied project

Fig. 3. Defense of the course project "Micro Thermal Power Plant"

in the company under the supervision of a professional.

Apart from the applied project based on the topic of the prospect graduation thesis, during the third and fourth years students carry out four course projects (course works), which aims at acquiring essential professional knowledge: "Design of Heat and Power Plants and Processes". "Boiler Plant". "Heat Engines", and "Industrial and Thermal Power Plants".

The essential condition to enhance the education process is proactive participation of strategic partners: leading energy companies interested in high quality staff. The companies currently participating in this process are as follows: Unipro PJSC, Siberian Generating Company, JSC "OGK-2", Danfoss, the engineering company "Powerz", and other regional and federal energy enterprises. These companies have significantly influenced the education programme in heat power engineering provided at Siberian Federal University. The cooperation between the company and university takes not only traditional forms (target preparation, scholarships, internship, participation state certification), but also imply informal arrangement on strategic partnership. This efficient partnership is secured through enhancing the department and laboratory facilities; organizing new working environment; co-funding student projects; formulating project topics, supporting and implementing projects; participating in career guidance activities; ensuring students' participation in Youth Councils of the company, as well as in other sport, artistic, and other corporative events.

The experience of Siberian Federal University in implementing project-based learning into Bachelor's degree programme in heat power engineering was approved by the experts of the strategic partners (potential employers), who are closely involved in holding project weeks. Moreover, this experience allowed increasing the performance indicator of many educational departments. Over the three years of the experiment (starting with 2014, when first students were admitted to the CDIO programme), the average grade of the Universal State Exams in the relevant disciplines has increased from 182.3 to 197.5, with the number of students admitted equal to 50. The students come from 18 region of the RF and 5 countries of the former Soviet Union, and the internationalization level of the programme has risen over the period from 1.2% to 16%. The number of students who were admitted and then graduated from the programme, has also increased, from 63% to 95%. Students' publication activity and the indicator of their participation in various

Fig. 4. Examples of implemented generating plant projects

a) Generating plant based on the Organic Rankine Cycle (1.2 kW)

b) Wind-solar-diesel plant (1 kW)

conferences and scientific and technical competitions hold at different levels has significantly improved and currently makes three times as much as it used to be at the beginning of the period.

However, one should also take into account the risks connected with implementation of a new educational technology, which are as follows: lack of competency which teaching and educational support staff have to admit since they do not possess enough experience in project development and implementation; insufficient university infrastructure and inadequate education programme of the department; need for significant management, institutional (at the university level), physical, and financial resources.

Although only the interim results of the project implementation have been indicated, one can clearly notice a number of objective and subjective advantages, which allows suggesting this approach not only to enhance engineering education of other profiles at Siberian Federal University, but also to improve the quality of heat power engineering programmes provided by other Russian universities.

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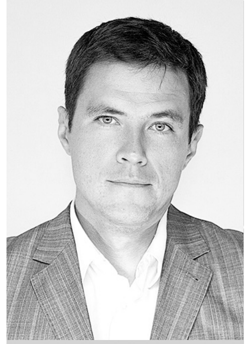

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Implementing CDIO Initiative in Russian Universities: Interim Results and Prospects

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Abstract
The paper describes interim results of implementing the CDIO initiative into education programmes of national universities. The author has indicated the trends in publishing academic papers on the topic. The factors hindering CDIO implementation into national education have been identified. The author gives recommendations and suggests the algorithm for implementing CDIO into the education programme of the Russian university.

Key words: training, engineering education, technical specialties, CDIO, education standards, publications.

Introduction

The future of the Russian society and national economy strongly depends on enhancements in the sphere of national education. Engineering training seems to be particularly important since the new technological era makes it necessary to revise the concept of engineering education. The RF is not the first one to face this challenge, and one of the solutions suggested at the turn of the 21st century was the CDIO Initiative, the idea developed in cooperation between Massachusetts Institute of Technology and several European universities. In the RF, the Initiative was adapted and adopted by a number of educational institutions in 2013, and over the past four years another ten universities have joined CDIO. However, no one has made an attempt to consolidate the efforts of researchers, professionals, and teachers interested in CDIO and to determine the prospects and trends of the CDIO Initiative development within the scope of the national education.

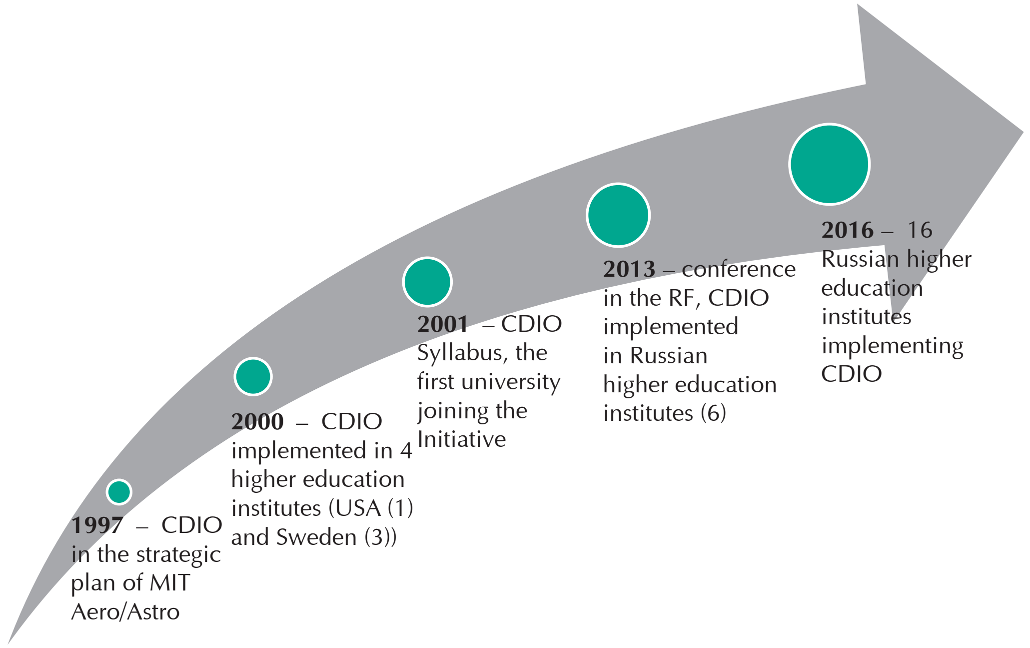
This is what the present paper deals with: the author analyses the interest in CDIO reflected in scientific publications, interprets the content, and determines the trends in CDIO development and implementation into the national education system.

CDIO in scientific publications: trends and priorities

The challenges within the system of higher education, and engineering higher education in particular, are an urgent issue for scientists, and many new approaches are currently suggested. One of them is the CDIO Initiative, an innovative multifaceted approach to engineering education, formulated as an idea in 1997 and then designed and implemented in 2001 in cooperation between Massachusetts Institute of technology (the USA) and universities of Sweden. The course of the events is given in fig. 1.

First publications on CDIO in Scopus are dated by 2002 and the topic has been gaining interest since then. In 2016, the annual number of Scopus publications dealing somehow with CDIO was six times as much as that in 2002: 5 and 30 publications, respectively (fig. 2).

Fig. 1. CDIO development on the global and national scales (the RF)



The number of publications in national journals has also increased (see the trend in eLIBRARY.ru given in fig.2). It is noteworthy that Russian scholars tended to be more interested in the topic than the foreign ones (in 2014, 112 publications in Russian Science Citation Index (RSCI) database compared to 54 publications in Scopus). The first article in Russian devoted to CDIO was published in 2011, and the interest to the topic reached its peak in 2014, when the journal Engineering Education published the issue focused on CDIO.

With the number of publications on CDIO topic increasing, it is possible to identify particular trends in the researchers' interest. However, one can notice that the majority of papers are published in conference proceedings rather than in scholarly editions: out of the total number of publications on CDIO in Scopus (410), there are 93 journal articles, 14 book chapters and paragraphs, and 286 proceeding papers.

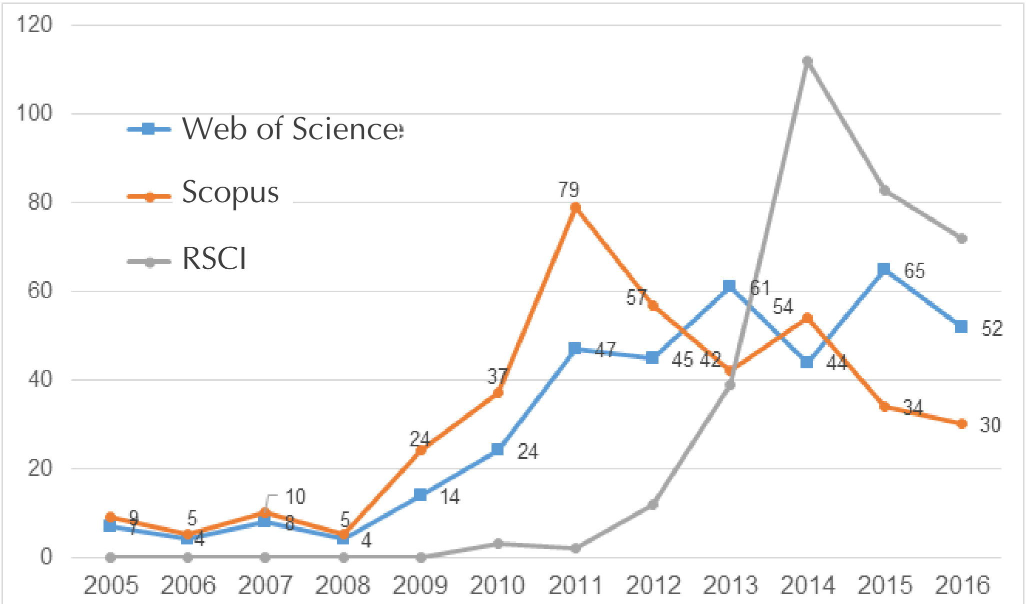
The analysis of publication activities carried out within the scope of the present research has shown that over the past 10 years the number of publications on CDIO had slightly decreased and reached a plateau (Scopus, Web of Science, and RSCI) (fig. 1). The research material included articles and conference proceedings published between 2000 and 2016, in which CDIO is used in the title, abstract and/or key words.

First appeared in more recent times, the interest to CDIO peaked in 2011–2013 (in foreign countries) and in 2013–2014 (in Russia), and then the number of publications became steady.

To identify the key trends within the scope of CDIO research, we have analyzed the content of the most cited (Scopus and RSCI) and most recently published papers. The publications were selected based on the term "CDIO" mentioned in the title. Over the period of 2000–2016, the number of publications in Scopus equals to 93. Table 1 presents a list of journals, in which the majority of papers on CDIO were published.

The most cited papers are those by Crawley, E.F., Brodeur, D.R., Soderholm, D.H. (2008) [1], Edstrum, K., Kolmos, A. (2014) [2], Lunev, A., Petrova, I., Zaripova,

Fig. 2. Publications on CDIO topic in Scopus, Web of Science, and RSCI



V. (2013) [3], Woollacott, L.C. (2009) [4], Padfield, G.D. (2006) [5], and Wang, Y., Qi, Z., Li, Z., Zhang, L. (2011) [6].

Among the papers published in Russian, the most cited are those by Gafurova N.V., Osipova S.I. (2013) [7], Chuchalin A.I. (2011) [8], Yakovlev A.N., Kostikov K.S., Martyushev N.V., Shepotenko N.A., Falkovich Yu.V. (2012) г. [9], Zamyatina O.M., Mozgaleva P. I. (2013) [10], Mineva O.K., Akmaeva R.I., Usacheva L.V. (2013) [11], Treshchev A.M., Sergeeva O.A. (2012) [12].

These papers deal with implementing CDIO into metallurgical engineering education, teaching mathematics for engineering students, stakeholders' expectations for proficiency based on CDIO standards implementation CDIO [13, 14].

Having analyzed the bulk of papers on CDIO Initiative (most cited and most recently published), one can drive to the conclusions as follows:

- the majority of papers are case studies dealing with CDIO implementation into the education programme; this proves the fact that the CDIO concept is to be clearly comprehended, interpreted, and consolidated;
- the research is conducted in leading engineering schools in China (41 publications in Scopus), the USA (8 publications), Russia (6 publications), and Sweden (6 publications);
- among the most cited papers, the only one belongs to the Russian scholars; however, it is clear that the experience of enhancing the system of engineering education in Russia should be further studied and transmitted throughout the global scientific community.

Table 1. Journals publishing academic papers on CDIO

Journal	Number of articles on CDIO
World Transactions on Engineering and Technology Education	18
European Journal of Engineering Education	5
Journal of Engineering Science and Technology	5
Australasian Journal of Engineering Education	4
Energy Education Science and Technology Part a Energy Science and Research	4

Let us analyze the CDIO approach in detail and identify the main trends in implementing CDIO in national engineering institutes.

The CDIO concept for engineering education

According to the definition of its designers, the CDIO Initiative is a multifaceted approach to engineering education (in particular, bachelor's degree programmes), which includes the key principles of programme design, material and technical support, staff recruitment and continuing professional development. The CDIO abbreviation comes from the key concepts: Conceive – Design – Implement – Operate. Therefore, CDIO is a complex framework for training engineers able to generate ideas, design, operate, and dispose engineering products [13]. The CDIO aim is to graduate an engineer who can create a new product or an idea, and then design and implement it.

In their paper, S.A. Podlesny and A.V. Kozlov mention that one of the challenges in CDIO implementation in Russia is the lack of laboratory equipment to conduct experiments and the lack of opportunities to implement and operate the products in real production [15]. Another disadvantage is poorly developed professional competencies of the academic staff, as well as the lack of opportunity to continue professional development in accordance with the CDIO standards.

The CDIO Standards (the total number is 12) were designed to standardize the procedure of CDIO implementation into education programmes provided by the institutes worldwide.

However, it is clear that the standard is a kind of archetype, an abstract model, against which other conditions and objects can be compared. There is a wide range of items to be standardized: products, services, activities and operations, documentation, etc. It is noteworthy that a standard is not a stiff requirement but a start point to enhance the activities since the standards themselves are regularly altered, which aims to improve the quality of education provided.

Since a higher education institute is of high social significance in Russia, the educational activities are almost totally standardized. Any deviation from the standard implies a number of options, which require additional efforts to be monitored and controlled. The quality of education provided higher education institutes is controlled by the Ministry of Education and Science and particular monitoring organizations, while the universities which joined the CDIO Initiative bear responsibility for meeting the relevant requirements. For a time, the Agency for Strategic Initiatives and Skoltech held themselves out as professionals in this sphere, however, the Initiative failed to be widely spread among the national universities, and over the past four years, only 10 higher education institutes have joined (Table 2).

Today, there are more than 100 practice-oriented universities worldwide involved in CDIO and implementing CDIO standards. The CDIO collaborators among national higher education institutes are Tomsk Polytechnic university, Skoltech, Astrakhan State University, Moscow Aviation Institute, Moscow Institute of Physics and Technology, Tomsk State University of Control Systems and Radioelectronics, etc. Actually, the CDIO Initiative has not been widely spread throughout the country and its future is not clear, first of all, due to resignation of Edward Crawley, one of the CDIO concept developers and founders,

Table 2. CDIO collaborators among national higher education institutes

№	National Higher Education Institute	Year of joining CDIO Association
1	Tomsk Polytechnic University	2011
2	Astrakhan State University	2012
3	Skolkovo Institute for Science and Technology	2012
4	Moscow Aviation Institute	2012
5	Tomsk State University of Control Systems and Radioelectronics	2013
6	Ural Federal University named after the first President of Russia B.N. Yeltsin	2013
7	Moscow Institute of Physics and Technology	2013
8	Siberian Federal University	2014
9	Kazan Federal University	2014
10	Don State Technical University	2014
11	Cherepovets State University	2014
12	National Research Nuclear University MEPhI	2014
13	The Ammosov North-Eastern Federal University	2015
14	Bauman Moscow State Technical University (BMSTU)	2015
15	Saint Petersburg State University of Aerospace Instrumentation	2015
16	Oryol State University	2016

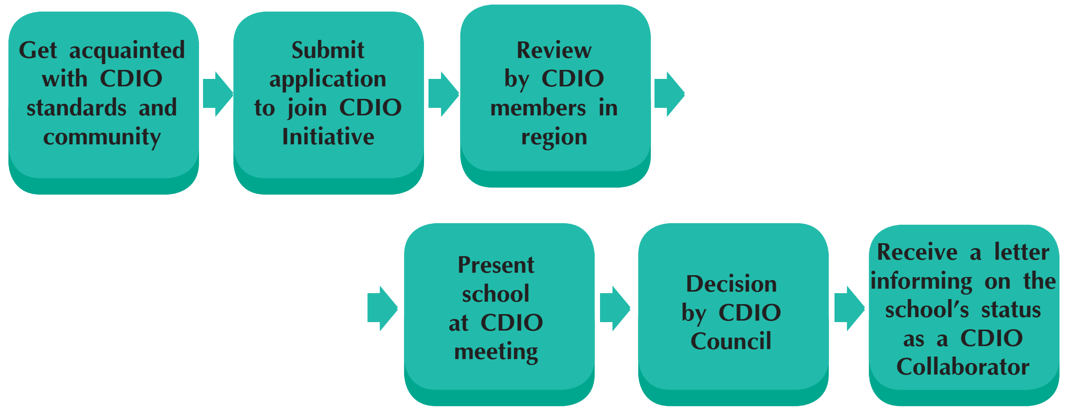
who quitted the post of Skolthech rector. It was professor Crawley who promoted CDIO in Russia and created awareness among the national universities beginning from 2013. It is symptomatic that in 2016 only one national university joined CDIO. Moreover, the advantages of participating in CDIO are not clear since all the standards are open (and even translated) and the university can follow the initiative without joining CDIO.

The steps to join the CDIO Initiatives are given in fig. 3.

As one can see from the figure above, the university should follow the formal procedure, and particular steps (such as presenting school at CDIO meeting) are time and money consuming. There is no formal procedure to control whether the university's educational approaches are appropriate to implement CDIO, and the conference registration fee is 425 €.

The intention of a university to join the CDIO Initiative is supported by neither the Agency for Strategic Initiatives nor Skoltech (which used to hold themselves out as CDIO collaborators in 2013). The last time the information on cdiorussia.ru was updated on July 9, 2013. The national community of CDIO collaborators has not been established. Therefore, the university, which intends to make their educational activities meet CDIO standards, can only join the CDIO Initiative all by themselves.

Fig. 3. Joining the Worldwide CDIO Initiative: series of steps



Conclusion

In conclusion, it is important to emphasize that the prospects of national engineering education are still a topical issue. The CDIO Initiative is one of the most transparent system, which creates a complex picture of adequate engineering education and essential tools to ensure the expected outcomes. In Russia, the rate of interest to the CDIO Initiative is higher than in other countries (except for China), but if the Asian scholars try to transmit their findings into international scientific community, the scholars of the RF publish their papers mostly in Russian.

Today, there are attempts to articulate the original vision of national engineering education, which can be developed as a streamline concept, like CDIO, however, these ideas are difficult to promote and implemented only at particular universities (as well as CDIO). Therefore, one can make a conclusion that none of the concepts on engineering education enhancement can be intensively developed and implemented in the RF without governmental support.

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On the Influence of the Bologna Process on Development of Higher Education in Russia

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Abstract

Among the educational community there is a common opinion of the negative impact of the Bologna process on the national higher education. In the context of FESTFU we can say that the transition to the two-tiered system of education has substantially changed educational and scientific activities of universities. Regulatory framework was developed for ensuring educational and research activities in the terms of the Bologna process. It includes updating teachers' activity, developing their educational and teaching culture, preparing them to effectively use the modern technologies in training and allowing them to bring educational process to a new level.

Key words: educational program, credit-modular system, competence, two-tiered education, teaching material, training.

As is known, in 2011 the Bologna Convention was firmly established in Russia. It had to provide convertibility of Russian diplomas and students'/teachers' academic mobility [2]. Russia's inclusion into European educational zone was suggested to give a strong impetus to integration in national higher education and improve the quality of educational services. This issue is nowadays particularly topical, as the intensive development and engineering innovations continuously change the conditions and quality of professional activity causing specialists to acquire new methods and types of professional skills and competencies as well as regularly improve their qualifications [7].

Strictly speaking, education transition to the Bologna process implies implementation of the four fundamental provisions defining future structure of higher education. It is, first of all, **two-tiered education** (Bachelor, Master) [2]. One can say that the problem was solved by all Russian universities, as there were several Bachelor graduations. However, up to now there are intensive debates among the university communities about the shift from Specialist degree to Bachelor degree training [3].

As I know from my experience as a member of State Examination Board, the difference between a bachelor and a specialist is much more than an additional academic year. Over the last study year as a specialist, the students additionally acquire nearly 50 % of competencies. Meanwhile, I remember the conference (2012), where two professors had a face-to-face argument about Bachelor degree. One of them said that a Bachelor is a half-educated specialist, so employers do not know how to treat it. The other professor argued that at our stores the commodities are produced by those half-trained bachelors from aboard (before import substitution period). So, not only study time matters here, but also smart management of production-oriented educational process.

It should be mentioned that teaching staff is aware of the Bologna process rather superficially, in an ordinary university teacher's opinion it is just two-level training system introduced instead of Specialist degree course [2]. This results in debates about necessity of changes, because everything was fine in the past and specialists were trained better than bachelors. It should be noted that in the past everything was not fine, and the higher education system had long needed to be fundamentally transformed [7].

Besides, there is a Master course, which includes an additional year as compared to Specialist course. So, Master students can be trained for all they wish. For example, one can train them for research, project, or other types of work necessary for industry. Perhaps, lack of teachers' knowledge in other work but research does not allow effective Master training for industry [6].

In Russia students do a Master course mainly to acquire specialized knowledge in practice areas, but not to do research [5]. Meanwhile, in the market-oriented countries Master courses have a function of training elite personnel, whose activity contributes to scientific-technological and social-economic progress. Hence, high-tech production development, i.e. the goal of European education in Russia, is not achieved again [8].

One more sensitive issue, which is beyond teachers' comprehension, is whether graduate departments will be in the university structure or they will be abolished as institutional units of research school [2]. In fact, when shifting from the linear principle of curriculum development to the branched one there is no division of departments into graduate and supporting (supplementary) ones. Due to the changes in "specialist's ideology" there are the changes in both education content and essence of a teacher's job [4]. However, it does not mean a complete elimination of this unit from university structure, as departments become not only resource-educational centers, but also research centers. At the moment a department is a club where all teachers speak the same language and about the same professional topics. A student at the department has to be satisfied with profile training. In case of absence of such an opportunity a student does not know how to satisfy his/her curiosity.

The second statement is **credits.** In this case we are dealing with principal changes in academic process planning [2]. In fact, a set of credits largely becomes a sole prerogative of a student, as he/she develops his/her own educational trajectory becoming a key and interested person in this system, who is fully responsible for all losses and gains of his/her education. It is those careless students who will be spoken of as not managing to plan their educational trajectory [8].

It is known that in Europe there is a long-standing need for students' individual trajectory. It was suggested that students would be given a chance to acquire those professional competencies that they consider to be valuable for themselves [5]. It allowed them to choose subject and teachers independently, and if they wished – to study at different European universities. Under the condition of global labour market the diploma recognized in different countries became more and more relevant, for this purpose the European community has reviewed the education system and developed a unified qualification of university graduates.

The criticism of Russian educational community is focused on **competence-based approach.** In European version this approach is considered in tight connection with **credit-modular system** of knowledge assessment [3]. Such a combination allows for individualization of student's educational trajectory that meets the contemporary challenges of global labour market.

The European education system provides student's individual educational trajectory, which meets current challenges of global labour market. The analysis of professional activity of the Russian university teaching staff, including Far Eastern State Technical Fisheries University, has shown that we still have dominating education system based on "knowledge - abilities – skills" model that exhausted its potentials of both content and teaching methods [8, 10]. Its alternative is competence-based approach, while all versions of the given approach developed in many universities over several years have not resulted in crucial improvement of education yet [6]. It is conditioned by the fact that for implementation of competence-based approach one needs to focus not only on future graduate's practical activity, but also definite competence-based **models of professional activity description.** Moreover, those methods require appropriate **methods of their development** [2]. The attempts to introduce the approach with insignificant corrections of existing forms and methods in university training developed on the basis of "knowledge - abilities - skills" model have not led to any quality changes in education and, therefore, do not actually increase the level of students' training [8].

To break the vicious circle, one needs to further enhancement of education content and methods, a shift to activity-based training giving a graduate opportunity to receive qualification demanded in the labour market not only at present but also in the short-term perspective [7]. Yet, effective implementation of modern educational standards is possible only if teaching staff acquires new competencies.

To implement the competence approach, it is necessary to further improve the content and methods of professional training, shift to activity-based learning making possible for a graduate not only to get qualification demanded in the labour market at present, but also in the short-term perspective, an actual certification of his/her competence and commitment for integration into production sphere [5].

It is known that **credit-modular system** of education quality assessment in its block-modular form was developed in Europe as a result of an urgent need in students' individual educational trajectory [2]. This phenomenon is not very typical for the Russian universities, which is explained by the lack of positive dynamics in demand for specialists having extended range of innovative competencies [4]. In the country the situation with graduate employment is deteriorating, as they mostly work in the spheres not related to their profiles [9]. It is mainly conditioned by the lack of extensive innovative activity in the production sphere, therefore, some authors argue that modernization of higher education following the Western European example did not make much sense from the very beginning, except for Russian graduate employment aboard [6].

The third statement is **mobility of both students and teachers.** It is suggested to stimulate doing additional courses at foreign universities. However, this useful action requires financial support for both students and teachers. Unfortunately, teaching staff and students are not native speakers; therefore, one can hardly speak about their mobility. As for exchange of teaching materials among the Russian universities one observes some intensification of the exchange, as all teaching materials are to be posted on the university sites.

In recent years, state policy in the sphere of higher education consists in regular and persistent explanation of measures that the rectors of Russian universities have to take to be competitive in the global education and science market, first of all, raise the quality of their educational programmes [4]. To solve this problem, the teaching staff of most Russian universities is to be taught English of not lower than basic level, so that teachers could be familiar with international scientific achievements and bring their teaching materials in compliance with current requirements. Language proficiency would greatly promote the teaching staff mobility, as one of the key factors impeding teachers' and students' mobility is low level of foreign language, particularly English. At many Russian universities there are no courses taught in English. Introduction of English curricula will not only contribute to mobility and competitiveness of Russian university teachers and students in the European market, but also significantly attract students from abroad, especially from CIS countries.

The fourth statement is **education quality assurance.** The system of university quality management is a combination of management structure, processes and resources necessary for effective quality policy by its planning, management, and enhancement [2]. The quality policy is the principle document, which defines the goal of quality management system as well as university authority's responsibility for achieving this goal.

At present a university management system is mandatory at all Russian universities, which implies development of university documents in the form of provisions, instructions, methodical guidelines and institutional standards on organization and control of academic process.

The first step in ensuring quality education is a shift to a student's responsibility. In this case a student is to have the right of choosing a teacher. In Russia we can observe a decrease in education quality at all levels. One of the reasons for this decrease is incorrect target-setting in the sphere of state quality policy in Russia.

One more novelty of the Bologna process is credit-modular system of knowledge assessment, which is one of the positive aspects [3]. The credit-modular system of knowledge assessment provides high accuracy and multi-dimension of students' learning outcomes on different subjects. The obvious benefits of the given system include practical elimination of subjectivity between teacher and student. Besides, it encourages developing the condition for students' in-depth study of definite subjects as well as development of their cognitive activity in view of students' individual preferences, interdisciplinary interactions and speciality [9]. Finally, credit-modular approach provides a higher level of students' autonomous work.

Obviously, a student's credit rating can hardly be exciting, let alone creative activity. Yet, a student can see all his/her activity or inactivity, and the final outcome is now not a result of a teacher's occasional or emotional relation to a student, as it is formed as a consequence of student's efforts made during the whole period of studying a subject. The disadvantages of the given knowledge assessment system in the Russian condition include high labour cost that can be conditioned by current imperfect computer technologies at some universities.

Now let us turn our attention to the changes in **teaching materials** of learning process. The researchers have stated that a characteristic feature of Russian universities regardless of their status is an overall bureaucracy of scientific-educational process, which can be seen in the form of management practice in all spheres of university [1]. In this context, university environment was many times formalized, where different standards, regulations, teachers' and employee's activity assessments were actively introduced. Moreover, all these years there was a total and unnecessary complication in reporting system, methodical resources, certification and other forms of assessment and self-assessment of teachers, students, institutions, and their administration.

Nevertheless, such things occur in nearly all spheres of professional activity of the entire working population in the country. Virtually no activity field can avoid the multi-level top-down control, which, in combination with enormous reporting paperwork, leaves little time to do real, let alone creative work.

This opinion can be only partially agreed with, as bureaucracy is confused with parameter formalization of research-educational process, in particular, development of standards and assessment criteria. The mentality of most university teachers is such that any formalization is treated negatively. In this case it is one of the most important principles of management streamlining and its efficiency improvement and is aimed at objectivity and transparency of control and management [5]. This allows us to reach a new level of teaching materials in academic process [1].

Most teachers are likely to consider this work a useless paperwork. Nevertheless, in this context there are modernization and organization of university structure, changes in logics and content of academic process [3]. Besides, development of university curricula, tests, and other teaching materials based on the FSES standards involves teachers' intensive self-improvement, as a result of which they develop **general teaching culture.** A substantial amount of teaching documents that is currently developed at universities is an occasional task on introduction of educational standards.

Thus, one can conclude that the transition to the two-tiered education system turns out to be complex and multidimensional, requires a stage-by-stage solution of complicated problems related to all university functions. Extensive work has been undertaken to improve legal and regulatory framework, as the corresponding laws and regulations were developed to ensure educational and research activity including formation of methodical base in the form of educational standards. Moreover, education modernization in terms of the Bologna process greatly updated teachers' activity, prepared them for effective use of modern educational technologies and allowed a new level of education. At present teaching materials are of such quality that they allow a university to function in the sphere of education, research, and other areas and, hence, to respond adequately to the current challenges.

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Engineering Educational Practices to Train Future Engineers in the USA

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Abstract
Based on the analysis of engineering educational practices in the USA as well as the governmental support of education programs, the article reveals strengths and weaknesses of stimulating the youth to choose engineering education and engineering professions.

Key words: educational practice, best practices, engineering education, university, the USA.

Human capital is one of the factors for providing competitiveness of a country in the market of high-tech production and in the fight for technological leadership. In this context, training of personnel for those industries, whose development enables the transition to the new technological stage, is of particular importance.

In the given research educational practices are taken as a study object. It should be noted that there is no common definition for "educational practice" in the national and foreign literature [1, p.77].

By best educational practices The National Governors Association Center for Best Practices (NGA Center) means a wide range of particular events, approaches, and strategies to provide positive changes either in students' attitude to learning or in their learning behavior. The following types of educational practices are distinguished: *promising education practices* that have not been assessed yet; *validated education practices* that have successfully been introduced independently on the number of applications in education and positively evaluated by students; and *exemplary education practices* that are distinguished by scaling-up and students' positive evaluation in every application [2].

Therefore, in the given research under *educational practice of engineering profile* we mean the events, means, techniques, and other types of activity aimed at students' practical acquiring special subject competencies in the sphere of engineering and natural science education as well as their introduction to definite jobs. In our case, exemplary education practices that were introduced at different institutions and can be scaled-up have been analyzed.

At present, the American universities are at the top of international university ratings in terms of specific engineering subject areas – Academic Ranking of World Universities [3], Times Higher Education ranking in the sphere of engineering and technology [4], the ranking of top world universities in the list of British consulting company Quacquarelli Symonds (QS) QS World University Rankings in the area of mechanics, aerospace and industrial engineering of 2016 [5].

Hence, based on the analysis of international ranking one can conclude that the USA, on the one hand, show high performance indicators in the spheres of disciplines related to natural science and mathematics (according to the analysis of scientometric data), on the other hand, the quality of engineering training at leading American universities meets the highest expectations of employers.

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The US government pays increased attention to development of natural science education in general and engineering education, in particular. Thus, as early as in November, 2009 President of the US Barack Obama announced the beginning of campaign to gain the US advantage in development of natural science, engineering, and mathematical education (Science, Technology, Engineering, and Mathematics (STEM) Education) called "Educate to Innovate".

In January, 2010 in the message of the President to the US Congress B. Obama extended the list of events in the frame of the given initiative with a view of achieving qualitative and quantitative indicators for the USA to become a leader in terms of school natural science and mathematics education within 10 years, to train more than 100 000 teachers of natural science subjects and math over the indicated period by means of public-private partnership, involvement of leading companies, universities, funds, non-governmental and governmental organizations in solving the problems of attracting, supporting, upgrading (including awarding system) highly qualified pedagogical staff teaching in STEM-fields [6].

In 2010 the amount of federal financial investment in development of natural science and mathematical education was 3.4 billion of US dollars. In 2013 80 % of resources allocated by the state for the strategic project were invested in the National Science Foundation, United States Department of Education and United States Department of Health and Human Services [7]. Moreover, in 2016 about 80 % of state expenditure allocated for support of natural science and mathematical education were also intended for these institutions. The 2017 budget provides 3 billion of US dollars to solve these problems [8].

Therefore, the strengths of the American system of engineering training are as follows:

- Governmental support of youth motivation programs for engineering professions. Since 1999 the National Science Foundation has implemented the program "Graduate STEM Fellows in K-12 Education (GK-12) Program)". In 1999 since the implementation of the given program more than 200 projects developed by 140 different universities of the US and Puerto-Rico were supported [9].

The amount of grant for this program is 600 000 US dollars within 5 years. Besides, the graduates working at schools receive annual allowance of 30 000 US dollars. In addition, a post-graduate's expenditure for medical insurance and study is compensated in the amount of 10 500 US dollars. The maximum post-graduate's work with pupils at schools do not last more than 10 hours per week, extra 5 hours per week are assigned for some other activities related to the project [10].

- Public participation in implementation of the projects and programs that are aimed at providing equal opportunities and motivating engagement of children of disadvantaged families and representatives of national minorities.

For example, the faculty members of University of Kentucky have launched the project "Utilizing STEM-camps and STEM-clubs to promote adolescent girls' and colored pupils' interest in STEM-fields". The project was supported by the National Science Foundation with the amount of 750000 US dollars. The goal of the project is to increase middle-grades students' interest and motivation in natural sciences by means of developing students' ideas about learning these spheres, work of scientists, mathematicians, and engineers. The main objectives of the project include research in the influence of learning informal environment of STEM-fields on the schoolchildren of the 5-8 grades (10 – 14 years old), particularly, girls and colored students through involving them in practical events held within summer STEM-camps and STEM-clubs open for schoolchildren all academic year long [11]. The project is to be implemented over 5 years – from 2013 till 2018.

Since 2010 the authors of the project have arranged summer STEM-camp "See Blue" with the support of College of Engineering, College of Education, College of Art and Science, University of Kentucky as well as teachers from the neighboring federal schools, representatives of expert communities. This camp was initially intended for 5-8 grades schoolchildren from low-income families. During a week children learnt such subjects as engineering design; visual mathematics based on evidence-based reasoning; neurobiology; sustainable development; astronomy and robotics using Lego.

■ High development of horizontal linkages in both engineers' professional spheres and among the institutions when implementing the projects in the field of youth's research-engineering activity.

In the USA various professional engineering associations and communities are established and operate. They are profession-, gender-, and race-based: Society of Biomedical Engineers, Society of Women Engineers, National Association of Black Engineers, Society of Hispanic Professional engineers, etc. Many of them organize university-based clubs/branches of the associations.

Hence, the students of engineering profiles have the possibility to participate in different programs of these associations, expand their professional network. The booklet published in 2013 for the students of Arizona State University contains information on 50 students' clubs and engineering associations with the representatives in this university [12];

Some American non-profit organizations develop educational modules to be used at school classes on natural sciences, mathematics, engineering, etc. For example, in 1997 non-profit organization "Project Lead the Way" developed the curriculum "Pathway to Engineering Program" for 12 schools of New-York. In 2012 United States Department of Education adapted the educational programs developed by "Project Lead the Way" as an example of conducting classes in STEM-fields [13, p.11].

At present the organization is implementing the curriculum in the field of engineering for the upper grades including different educational modules in such disciplines as aerocosmic engineering, civil engineering and architecture; engineering design, etc. This program is integrated in education program US Community Colleges that allows upper grade students who studied and passed the university exams on such subjects as engineering, biomedical science, and information to receive bonuses for university entry [14]. A student's score is taken into account when enrolling the university. For example, to get three points in 5-point scale established by the US Community Collages an upper grade student has to learn a course of Community Colleges curriculum, one of "Project Lead the Way" and the third chosen from educational programs of these organizations. Three points define the student's readiness for university training [15].

The Museum of Science (Boston) developed the curriculum "Engineering is Elementary" for elementary students funded by the National Science Foundation and partner companies. The curriculum includes several educational modules that can be used in classes and extracurricular work in such profiles as "acoustic engineering", "aerospace engineering", "mechanic engineering", and etc. [16] Educational modules were developed in terms of the standards for technological literacy of International Technology and Engineering Educators Association [17] and the standards of scientific literacy [18].

■ Developed facilities and resources of universities and research centers to be used in research and education.

One of the most successful practices in organizing clubs of research-technical art for the youth in the USA is the program of *Center for Bits and Atoms, Massachusetts Institute of Technology* to develop the network of invention laboratories (fab lab) – small work-shops fitted with special equipment that allows learners to perform numerical modeling and production operations using adaptive and subtractive methods. The program was launched in 2001 supported by the National Science Foundation. Nowadays there are 705 fab labs in 88 countries all over the world [19]. The members of the American fab lad network (U.S. Fab Lab Network) are more than 50 colleges, universities, and other educational institutions and research centers in 27 US states [20].

In addition, a number of US private universities have clubs of 3-D print arranged similarly to fab labs and fitted with various kinds of 3-D modeling and printing equipment. This club was opened for students of Brandeis University for a fee. The fee depends on the time spent for work with equipment [21].

■ A wide range of research-engineering competitions held at the federal and regional levels.

For example, Ohayo Northern University arranges the competition TEAMS (Tests of Engineering Aptitude, Mathematics, and Science) for middle and high school students. The competition is held for one day and aimed at development of students' creative skills in solving complex problems that have been defined by the US National Academy of Engineering as priorities [22]. They include improvement of cost efficiency of solar energy, energy production from synthesis, development of carbon sequestration methods; nitrogen cycle control; pure water supply; reconstruction and improvement of urban infrastructure; development of health communication; artificial intellect; design of virtual reality, etc. [23].

The drawbacks of this system are as follows:

■ Low performance of educational practices, one of the reasons for which is absence of unified standards for engineering training in STEM-fields, low youth's interest in engineering professions.

The experts pay attention to the fact that there are no unified school training requirements as opposed to those for mathematics and engineering. Therefore, engineering is still a weak link in the strategy of school education development and a missed letter in the abbreviation STEM [24, p. 38].

■ Lack of integration of practices into school and university educational programs since different clubs of research-engineering art do not serve as a tool to enhance academic performance of schoolchildren and students, but perform a function of vocational centers for training and networking among the specialists in STEM-fields. The exception is educational programs of Community Colleges and "Project Lead the Way". However, the score received by high school students within the course is not an admission score for university, but it only contributes to an applicant's portfolio.

Despite the highlighted challenges, implementation of educational practices in the US engineering training allows increasing the number of highly-qualified specialists in STEM-fields in a medium-term perspective.

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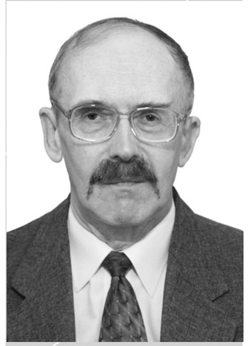

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Implementation Features of Interdisciplinary Relationships in the System of University Training of Specialists in the Field of Mechanical Engineering, 15.04.01, and the Enhancement of the Role of Technical Specialists in Contemporary Society

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Abstract

The paper considers major requirements for development of interdisciplinary relationships model during specialists training in Mechanical Engineering, in order to enhance their role in contemporary society.

Key words: interdisciplinary relationships, research activities, functional components, special courses.

Introduction

In order to determine structural elements of interaction between disciplines, the use of complex professionally-oriented interdisciplinary relationships allows to achieve the unity of common education goals and also to lend the system of study of specially designed courses (disciplines) the integrity and logical consistency. Implementation of interdisciplinary relationships is a certain system, which includes interrelated functional units, such as **identification, establishment, and implementation** of interacting interdisciplinary relationships [1-5].

We allocate interdisciplinary relationships so as to study the system of courses (disciplines), which is designed to improve the quality of specialists training in Mechanical Engineering and to enhance research work in technical universities. Additionally, this system is used to prepare students for project, analytical and research work. The entire pedagogical system in technical universities with its structural and functional components belongs to the external environment. It is a high-level system in relation to the allocated system of interdisciplinary relationships during implementation of special courses (subjects). Structural components of the pedagogical system, such as the teacher, the goal, the teaching information, the means of pedagogical communication, the students, are also structural components of interdisciplinary relationships subsystem [3-10]. Their functional components are intended to implement the goal of the allocated system. In turn, this system will be the element of the overall goal of pedagogical system. The allocated goal of the system coincides with that of the general pedagogical system at universities, which consists in **training qualified specialists for contemporary knowledge-intensive industries in the field of Mechanical Engineering** [1-6, 8-10].

Design of Interdisciplinary Relationships

The specific impact on interdisciplinary relationships, on improvement of professionals training for automotive industry is determined by the integrated scientific knowledge system with a high degree of awareness, mobility and strength. This system is based on interdisciplinary relationships. Therefore, the system of courses (subjects) in a certain field needs a **model of interdisciplinary relationships.** On the one hand, this model would highlight features of interdisciplinary relationships and, on the other hand, it would be the integral part and, therefore, would develop the general model of professional training in Mechanical Engineering. Hereby, the model would be related to the ultimate goal of training specialists in the system of higher education. In this case,

- professional and qualification features of specialists reflected in the professional standard or the Federal State Educational Standard in a certain field, must be the basis for identification of interdisciplinary relationships, i.e. their architectonic foundation;
- in the course of attending specialty courses in certain fields,
- this model must identify both intradisciplinary and interdisciplinary relationships;
- interdisciplinary relationships must be of professional orientation of all disciplines belonging to studied professions;
- this model must provide for transformation ways of interdisciplinary relationships of specialty courses system across certain issues with other disciplines, i.e. transformation from successive to preceding disciplines;
- it is required to provide for a scientifically grounded and practically acceptable recording method of interdisciplinary relationships;
- this model must determine optimal conditions for implementation of professionally-oriented intradisciplinary and interdisciplinary relationships in the study of specialty courses system in regards to certain issues.

The above-mentioned content analysis of interdisciplinary relationships and the allocation of requirements for modeling this process, make it possible to develop the model of **professionally-oriented interdisciplinary relationships during the study of courses system (disciplines)**. This model can be designed based on the goal of higher professional education, which consists in executing social services of society to train and educate future specialists in the field of Mechanical Engineering. Each model unit implements certain methods of interdisciplinary relationships. Therefore, each unit has its own functions.

The relationship between training content and content of future activities of specialists in the field of Mechanical Engineering is the function of unit **"Identification of structural elements of the relationship between disciplines through the feature of professional skills".** To reveal structural elements of relationships between disciplines, the analysis method of production activity of future specialists by means of features of professional skills is employed. Also, these elements are grouped on the basis of general scientific professional knowledge. At the same time, the feature of professional skills is considered as the objective basis for determining structural elements of theoretical disciplines content and industrial training, since it specifically determines the socio-economic and national economic importance of the future study field. The repeated in two or more disciplines structural elements of education content serve as the relationship structural elements between disciplines. Still, these interdisciplinary relationships are streamlined neither in relation to certain disciplines, nor in time. However, the employment of the feature of professional skills makes it possible to take the first step in establishing interdisciplinary relationships required for the study of certain professions.

The second unit, **"The establishment of intradisciplinary relationships within the system of specialty courses in regards to**

the common problem by using training analysis" determines the logic of training content in one discipline. The third unit, **"The analysis of temporal relationship between courses (disciplines) with other subjects (disciplines)"** determines the logic of learning material of a profession in its entirety. These two units are interrelated, because to identify both intradisciplinary and interdisciplinary relationships, it is required to analyze the curricula. This analysis is needed because the curriculum may not fully meet the demands of the given university, due to the specific character of its work and the logic of course presentation. We agree with the opinion of A. A. Pinsky and G. M. Golin, that "there is not any immanent and predefined student course logic, which would forcefully impose only one structure of teaching and learning management" [11]. Curriculum analysis may require adjustments either to improve intradisciplinary relationships from succeeding and preceding ones or, ultimately, to improve the professional orientation of curriculum. The latter is achieved by correlating the curriculum to the specificity of the back-up company. After the curriculum analysis, experienced teachers offer proposals, which are discussed and approved by acceptance boards with the expertise of several board members. During some timeframe, analysis materials that contain comments and suggestions to improve the curriculum, are verified. Afterwards, the curriculum is modified and finalized. Here we need to employ the method, which would assist in avoiding subjectivity in evaluation. Delphi approach, which is used to determine the optimal number of hours for disciplines topics, belongs to this method. Additionally, it is matrix analysis, which is based on expert assessment and allows to study the sequence of learning material and identify the optimal structure of its content. Finally, it is network planning of teaching and learning activities, which identifies classes linked by interdisciplinary relationships and the record of their temporal dependence.

The unit **"Recording interdisciplinary relationships"** has secured the instrumental function, i.e. to precondition the employment of interdisciplinary relationships.

The unit **"Selection of conditions for optimum implementation of interdisciplinary relationships"** performs the training function and covers content, methods and training aids. Interdisciplinary relationships are implemented both in classroom environment and during non-school hours. The latter include conferences, seminars, lectures, excursions, etc. In classes, these relationships influence the teacher's choice of training methods and materialize with the method. This contributes to the achievement of the class goal. Throughout the implementation of interdisciplinary relationships, related components of the syllabus must have a uniform interpretation of concepts, a uniform generally accepted terminology, a uniform system of measurements, etc. Interdisciplinary relationships are expressed through the same training equipment employed in classes when studying various disciplines.

Conclusion

With regards to the training programme of future specialists based on professional orientation of courses system (disciplines), the design of interdisciplinary relationships in the context of the considered units and their mutual dependence in the **system of courses (disciplines) study** covers **identification, recording and implementation** of interdisciplinary relationships in their entirety.

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Ways of Implementing Professional Specialist Training for Defence Industry Complex

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Abstract

The paper introduces the description of learning environment, which accumulates the resources of scientific, educational and production structures and allows ensuring the participation of students and master students in learning, scientific and research activities. Creation of practical-oriented environment within the integrated scientific, educational and production structures allows implementing the educational technologies for practical-oriented learning based on the activity approach and expanding the use of problem- and project-based learning for creating the innovative ideas.

Key words: professional training, advanced practice-oriented learning, specialized department, integrated scientific, educational and production structures.

Introduction

Higher educational institutions should search for effective learning techniques to solve the problem of shortage of qualified employees in the Defence Industry Complex (DIC). These techniques should improve the quality of education, professional competence and mobility of the future professionals. This leads to the changes in the existing talent development framework for the DIC.

High level of readiness to professional environment means creative self-realization of a professional expressed in transformation of the professional medium components into development of innovative products and technologies; optimization of methods and means of solving the professional tasks; introduction of institutional innovations etc.

To improve the quality of training the staff for the DIC of the RF the Ministry of Education and Science selects the universities on a competitive basis and provides them with the additional funds for target admission of applicants, improvement of technical equipment for learning process, the university and the DIC joint organization of target training of students for certain industry. Starting on 28 December 2007 and for the period until 2020 the Government of the Russian Federation has proposed the strategy of developing the system of multilevel permanent education (primary, secondary, higher and professional) in the defense industry complex. The system includes the measures in employee retention in the DIC, development of the specialized departments, industry graduate schools, as well as refresher course and advanced professional training of engineers, employees based on large integrated structures.

Creation of educational profession-oriented environment

The integrated structures have an opportunity to train certain amount of highly skilled professionals with the appropriate set of competence according to the requirements of the enterprises, allow organizing testing sites for scientific and innovation activities, and practice-oriented ones for development and testing different types of adaptive educational programs.

The content of educational programs should be changed and new organizational forms and methods of training professionals for the DIC such as on-line teaching, network forms of implementing educational programs, simulation of situations, youth scientific conference with elements of scientific schools should be found for ensuring advanced practice-oriented training and adapting the content of professional training to the dynamic professional environment.

The base for successful implementation of educational programs of staff training for high-tech sectors of economy on the basis of large integrated structures is the creation of the education environment which accumulates the resources of scientific, educational and production structures and allows ensuring the participation of students and master students in scientific and innovation activity [1].

It is possible to create such environment within the integrated scientific, educational and production structures (specialized departments), training the professionals, researching in certain scientific field and using the results in production and education.

Tambov State Technical University trains professionals for the DIC for the following training areas: 11.03.03 "Design engineering and technology of electronic aids", 11.03.02 "Information and communication technologies and communication systems", 11.03.01 "Radio engineering", as well as master students' магистров по направлениям подготовки 11.04.03 "Design engineering and technology of electronic aids" and 11.04.01 "Radio engineering".

The education institutions have to change the professional training process considering the requirements of enterprises, changes in technical and social progress, in new production technologies, in organization and content of professional activity of the DIC staff. It is necessary to create the special practice-oriented environment, which accumulates the resources of scientific, educational and production structures.

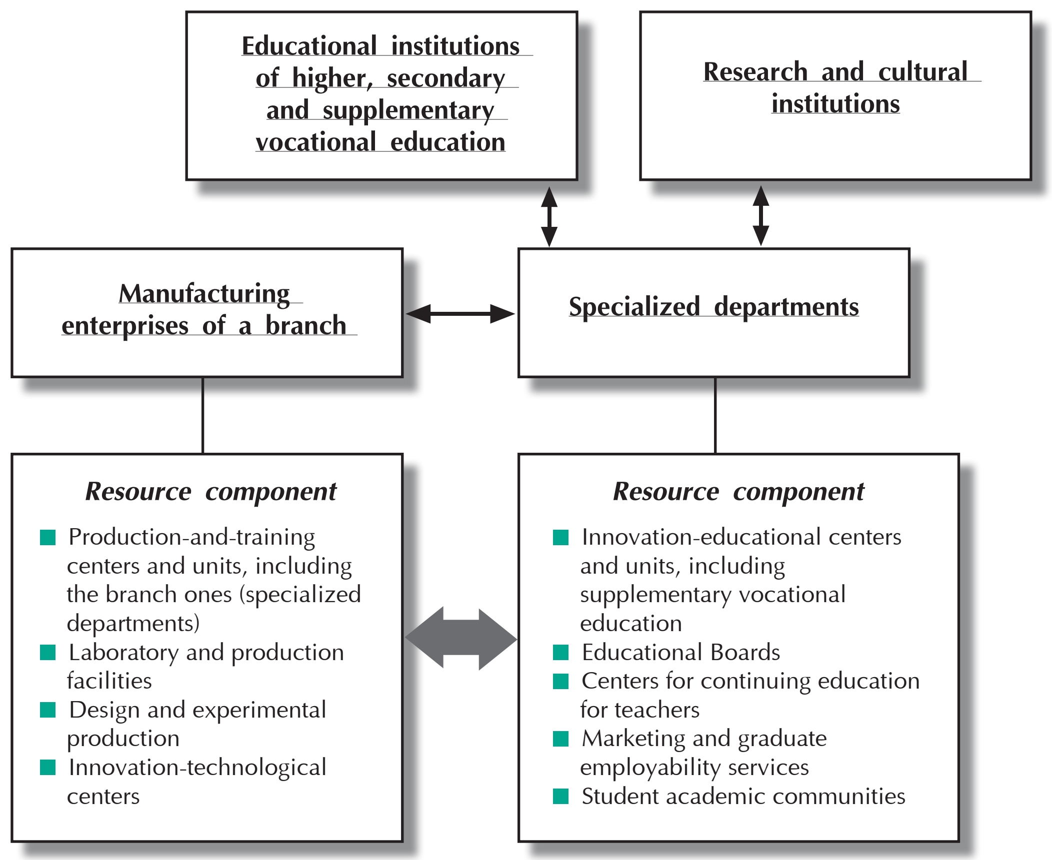
When designing such environment the approach introduced in the work of V.A. Yasvin was used. The author determines the environments as a system of effects and conditions of a personality formation as well as the possibilities for self-improvement in his/her environment [2]. For pedagogical mastering the environment, it is necessary, first of all, to single out and describe its components. V.A. Yasvin in his work analyzes the interaction of a personality and educational environment, proposes the system of psychological and pedagogical design of person-centered developing environments which are based on a concept of educational environment design space model including the subjects of learning process; social, space-object and technological components.

The Fig. 1 demonstrates the model of practice-oriented environment, which makes the learning process closer to real conditions of professional activity.

The features of the practice-oriented environment within the integrated scientific, educational and production structures are inclusion of the enterprise professionals and researchers as equal participants of educational process; use of resources of the DIC manufacturing enterprises and upgrade of training content according to industrial trends in the region and production, along with materials and equipment and information resources of educational institution.

Free access of students not only to information resources of educational institutions but also to the resources of the DIC manufacturing enterprises provides favorable conditions for graduates adaptation to high-tech manufacturing environment; intensifies the process of formation of instrumental and professional competences; encourages creative self-expression of future professionals. The DIC enterprise staff not only implement the educational programs, they develop the programs, determine new perspective activities, develop target training content; prepare teaching materials of educational

Fig. 1. Model of practice-oriented environment within the integrated scientific, educational and production structures



modules; organize and carry out laboratory practice in production conditions, advising students engaged in research.

Creation of the practice-oriented environment within the integrated scientific, educational and production structures (specialized departments) allows implementing educational technologies of practice-oriented learning based on the activity approach and including the innovative project method (integration of problem- and project-based learning and TRIZ – Theory of Inventive Problem Solving). These technologies are formed for implementing Product Lifecycle Management (PLM) when designing and producing IT-based high technology products. The key component of the PLM are: Product Data Management (PDM), Collaborative Product Development (CPD), Computer-Assisted Design (CAD), Computer Aided Engineering (CAE), Manufacturing Planning Management (MPM), as well as educational technologies expanding application of problem- and project-based learning and aimed at creating the innovative ideas.

First of all, these are the methods developed within the Global Initiative of training CDIO engineers (Conceive – Design – Implement – Operate). Within the frames of these educational technologies, the interactive methods are implemented. They create divergent thinking («brainstorm», morphological analysis, focal object methods, planned error method), convergent thinking (synectics, analogues, case analysis, incident method) and widely used TRIZ and cognitive technologies (IT focused on creation a person intellectual abilities).

When developing the educational technologies the differential learning regularities are taken into account, the optimal conditions for detecting abilities, cultivating interests and capabilities are made and mechanisms of the program material acquisition at different levels considering certain tasks of human resource development at the DIC are implemented.

The authors refer the principles of consistency, professional character, relevance, focus on a personality, self-fulfillment and self-reflection, synergism and focus on innovation, to the methodological system, professional training of the staff for the DIC within the practice-oriented environment of the integrated scientific, educational and production structures.

All the components of the practice-oriented environment aim at implementation of such functions as: training, learning, adaptive, information, communicative, technical and scientific. The practice-oriented environment relevant to the professional one and created in the context of integration of science, education and production allows bringing the learning process closer to real conditions of professional activity, allows the students to "fall into" the problem similar to the professional one, that promote the formation of students' systematic vision of the functions carried out by the professional, set strong inner motivation for solving the professional tasks.

Every year the 5–7 graduates with successful target training hold the permanent posts of the specialized departments. In this way the graduate employment issue is solved.

Conclusion

Thus, professional training within the practice-oriented environment of the integrated scientific, educational and production structures allows ensuring the required level of the graduates readiness to professional activity in DIC, minimizing educational and social difficulties in adapting to professional environment, expands the participation of students and master students in research, in grant winning, solves the graduates employment issue, creates the conditions for improving the staff quality structure; forms the generalized intellectual-creative space of university life; promotes the development of the system of permanent interaction between the employers and educational community for monitoring regional labor and educational service market, rational filling of business segments on labor market; encourages the employers to invest in educational institutions.

The integration processes promote, in their turn, the formation of the Common Education Space due to the joining information spaces of universities, scientific organizations and production structures, transfer and efficient use of concepts, ideas, principles, knowledge, methods and technologies from some fields to another ones and development of new forms of collective activity.

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UDC 378

Developing Managerial Competencies of Master's Civil Engineering Students By Intoducing Modern Teaching Techniques

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Abstract

The article proposes the design of a unique course "Design HR engineering" for master's civil engineering students, which is aimed at shaping managerial competencies. The course is intended to develop managerial competencies by means of active teaching techniques: business games, project teams, case-studies, workshops. These teaching techniques contribute to developing leadership skills within the formats that are familiar to future engineers (engineering and project-based approach).

Key words: leadership, project team, managerial competencies, engineering education, managerial techniques and tools.

Introduction

The modern economy of Russia has challenged the education system in terms of the need for revision of the programmes in order to train a highly-skilled leader who is able to make breakthroughs in technological fields.

According to the data presented in journal "Engineering Education", more than 60 % of students enrolled in various engineering programmes demonstrate low or middle level of leadership skills, which does not meet the Washington Accord (WA) requirements. This contradiction between the development level, requirements towards graduates' leadership skills and EQ structures allows drawing conclusion on the cause-effect relationship between improvement of professional and leadership skills of higher engineering universities' graduates and engineering education system itself [1, p. 121].

Introduction of competency-based approach into the system of higher engineering education, stated in the Federal State Education Standard of Higher Education and professional standards, is one of the most important changes in recent years. E.V. Galanina noted: "the standards of engineering education in Russian is currently being revised, i.e. waiver of narrow focus of most engineering programmes and so-called "humanitarian, communicative-oriented shift" [2].

However, despite the positive trends, there are still certain traditional contradictions in engineering education. Precisely, interdisciplinary principle and project-oriented approach have not been sufficiently implemented. There is lack of management programmes.

Implementing new approach to engineering training

In our opinion, traditional approaches to designing and implementing education programmes, as well as functional principle in defining the disciplines for students to attend, are the reasons for the above-mentioned contradictions. According to the learning outcomes of master's civil engineering programmes, students should be trained not only within technical spheres, but also acquire knowledge of business communication with resource providers, personnel, and customers, work as a member of project teams, assume responsibility, in other words, they should be able to apply the required strategies and technologies in human resources management.

A young highly-skilled civil engineer may build his/her career within a short time and occupy senior position at the age of 25-30. Such managers often do not satisfy basic requirements, which leads to disappointment in the chosen profession and his/her competence. Technocracy is not always successful. To manage effectively, a young manager needs to shape basic skills of project management, management of human resources, situation-related leadership, and team work. Thus, the need to develop these skills as the result of engineering programme completion is obvious. The socio-humanitarian disciplines embedded into engineering programmes are usually taught in traditional manner. Such didactic approach to training engineers is insufficient as they need knowledge of real influence tactics upon their subordinates and interpersonal communication, ability to predict the consequences of their social activity. Therefore, it is urgent to search for new disciplines and training techniques.

Competency-based approach stated in the Federal State Education Standards of Higher Education (FSES HE) is an adequate training tool in modern knowledge-based economy. New version of the FSES HE includes cross-cultural and integrated professional competencies of an engineer-manager (CCC-2, IPC-2, IPC-3, PC-15, PC-17) which can be hardly developed within the traditional humanitarian disciplines, as well as some professional ones. There is a need to search for new training tools and formats.

The review of the recent education techniques, related to the same spectrum of problems and tasks within master's engineering programmes both in Russia and abroad, has revealed the facts presented in table 1.

In Russia, engineering education is modernized on the basis of the CDIO concept [3] which is aimed at training graduates who are ready for complex engineering activity at all stages of the life cycle of products, processes and systems.

Overseas experience shows that most advanced and some developing countries have already created or have been creating conditions for implementing the CDIO initiative. The programmes include necessary disciplines and courses.

The analysis of more than 60 Russian master's programmes "Civil engineering" offered at 8 national research technical universities and 4 civil engineering universities has shown that the mentioned-above competencies are basically shaped within humanitarian disciplines, such as "Fundamentals of Pedagogy and Andragogy" (50 programmes), "Pshychology and ethics of business communication", "Social, psychological, and legal communications", "Research fundamentals", "Fundamentals of professional activity" (these disciplines take the 2nd place), as well as final state certification and teaching practice. "Philosophical issues of science and engineering", "Planning and management in civil engineering", "Quality management", "Methods to solve research and engineering tasks in civil engineering" which are not necessary aimed at shaping the discussed competencies are less common. It is possible to state that trying to introduce modern teaching techniques universities follow the tradition and do not always incorporate more relevant disciplines and courses. There is only one programme "Value engineering", offered by Rostov University of Architecture and Civil Engineering, that includes the discipline "Management of human resources". This discipline is closest to the idea of shaping managerial competencies.

At Industrial University of Tyumen, due to the program of higher education "Personnel management" that has been successfully implemented for more than 10 years,

Table1. Education techniques analysis

University/education standard	Practice	Main trends
International experience		
International standards CDIO – (Conceive, Design, Implement, Operate), MIT (Massachusetts Institute of Technology)	According to the CDIO concept, engineering education revision is rooted in training graduates who are ready for complex engineering activity	The standards imply consistent training of engineers who are able to generate idea, design, to produce, operate and utilize the products of engineering activity – perform 4 basic engineering activities
RMUTT Rajamangala University of Technology Thanyaburi (RMUTT), Thailand	Industrial engineering programme/ Programme implementation – 2015	The focus is made on shaping and developing communication and interpersonal skills, as well as ability to work in a project team. The discipline "Management of Human Resources" is introduced in the second semester of the first year of education
Singapore Polytechnic, Сингапур	New adapted vocational programmes have been developed. They are based on the learning outcomes stated in the CDIO concept	In addition to fundamental competences, there are also the following competencies: ability to solve problems, ability to manage human resources, skills in team work and interpersonal communication
University of Debrecen	It is currently addressing the issue of "poor training of engineering graduates in terms of professional and universal skills and competencies"	Humanitarian sciences and economics account for 16% of work load; various interdisciplinary programmes are designed
National universities		
National Research Tomsk Polytechnic University	In 2012, new version of «Standards and guidance on ensuring quality of basic education programmes on priority directions of university development" was implemented	Additional education programme "Elite engineering education" implemented alongside basic programmes was developed. The programme includes module "Innovative leadership"
Siberian Federal University	Training techniques and professional competencies are developed within the programmes of the project "Special engineering education" at networking	The curriculum of discipline "Design fundamentals" includes the module "Company project management" which incorporates «Company and personnel management", "Leadership programme" (Leader and team work – practical course)
Kazan National Research technological University	Training graduates for "the economy of new knowledge"	The focus is made on shaping leadership skills, individual intellectual resources within the module "Psychology"
Northern (Arctic) Federal University	Engineering education programmes are revised according to the CDIO concept	The programmes include: strategic planning, research practice, internship, management practice

University/education standard	Practice	Main trends
Gubkin Russian State University of Oil and Gas	Interdisciplinary approach is implemented into innovative projects of the university of the 21st century aimed at developing competencies of young specialists and engineers	"Virtual environment of professional activity as education environment" and "Joint virtual training for students of various programmes" are of particular interest. The disadvantage is complex methodology in development of cases
Peter the Great St. Petersburg Polytechnic University	Additional education programmes "Manager of a building company", etc., aimed at shaping economy related and managerial competencies	Module 10 "Personnel management" Module 2. Management of project team in programme "Economy and organization of constructions" Module 9 "Business communication and personnel management" in the programme "Manager of a building company"
Universities of civil engineering (based on website monitoring)		
Moscow State University of Civil Engineering, Saint Petersburg State University of Architecture and Civil Engineering, Novosibirsk State University of Architecture and Civil Engineering, Rostov University of Architecture and Civil Engineering	Disciplines and practice courses: Philosophical issues in science and engineering; Social, psychological and legal communication; Planning and management of transport facilities construction; Mathematical modelling; Methods for problem solving in civil engineering; Quality management in road construction; New composite road-building materials; internship aimed at shaping basic professional competencies and teaching skills); State Final Certification	The programmes are mainly compiled on the basis of didactic approach, with certain disciplines (internship plans) including development of the required competencies. There is no complex system of shaping managerial competencies
Tyumen Industrial University		
Tyumen Industrial University	Disciplines and practice courses: Psychology and ethics of professional activity; Personnel management; Research practice; Internship aimed at shaping professional competencies and skills; State Final Examination	The programmes are mainly compiled on the basis of didactic approach, with certain disciplines (internship plans) including development of the required competencies. The managerial competence is shaped due to introduction of great number of courses on management of personnel, company, and projects into various programmes

the special training approach that helps educators shape the required competencies was developed. It implies introduction of discipline "Personnel management" as a basic subject of B1 cycle (the 2nd semester) into all master's programmes offered at the university. This discipline is an interdisciplinary course which is rather labor-intensive and characterized by the structure given in table 2 (by the example of master's programme "Management of building company", 08.04.01 "Civil engineering in terms of acquired competencies").

The discipline is delivered on the basis of the HR-engineering and project management principles.

HR-engineering is a systemic management of human resources which allows integrating an employee into corporate structure and information technologies. Methodology of HR-engineering is rooted in the systemic approach (basic methodology), business engineering and socio-psychological approaches.

The methodology of the project-based approach which is initially an integrated component of civil engineering programmes is also proposed as a basic one in delivering "Personal Management". Upon this discipline completion, graduates acquire managerial competencies within the following domains:

- systemic knowledge of HR management;
- basis for globalization and localization of project management as a professional activity;
- mechanism to define functional structural tasks, formulate the tasks for a project team in various management systems including functional and cross-organizational systems;
- mechanism to build a project team;

Table 2. "Personnel Management" discipline structure

Competencies	Lecture topics
CCC-2 – readiness to act under non-standard conditions, assume social and ethic responsibility for taken decision	HR-engineering fundamentals Corporate culture as a managerial resource of a supervisor
IPC-2 – readiness to manage people in the sphere of his/her professional activity, be tolerant to social, ethic, confessional, and cultural differences	Fundamentals of team leadership Forms and technologies of managerial activity. Motivation and performance evaluation Fundamentals of professional communication
IPC-3 – ability to apply knowledge and skills in managing research and manufacturing activities, building teams, affecting team goals and socio-psychological climate in the required manner, as well as readiness for intensive social mobility	Design of professional teams Engineering of supervisor's personal work. Bases of time management

- common language and terminology for project management specialists (civil engineers).

The novelty of the project is due to applying innovative teaching techniques in order to shape the required competencies. These innovative techniques aimed at training adult people include skills workshops, case-studies, business games, project teams. For example, skills workshop "Slalom", business game "Marafup" [4, P. 271], business game "Interview", practice course «Diagnostics of moral and psychological climate in a team by sociometry", case-study "Conflict at Research and Design Institute", practice course "Analysis of cross-cultural interactions", etc.

Conclusion

The proposed course can be implemented as "Design HR-engineering". It is studied in the 2nd semester (17 lectures and 34 hours of practical classes) and it is an adequate response to employees' requirements. The course provides graduates with knowledge of HR management in civil engineering (design, manufacturing and other companies), equip them with team management skills by the example of real situations and case-studies.

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Simulation in professional education

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Abstract

The article is devoted to the issues of simulation as means of research in professional education. A classification of pedagogical models is developed according to their most essential features: application area, form, structure, subject of research, development in time, level of reflection of system's core features, level of specification, problem broadness. A brief explication is provided for each class of models. Definitions of the terms "model of a specialist" and "model of specialist's training" are proposed..

Key words: professional education, simulation, classification, model of a specialist, model of specialist's training.

Problem identification

The terms "model", "simulation" are widely used in pedagogical literature, when speaking about educational and tutoring processes. Thus, in "Pedagogical Constitution of Europe" adopted in 2013 by the Association of Rectors of Pedagogical Universities in Europe, among the constituents of the pedagogical strategy as a philosophy of education the principles of "functioning and implementation of educational models and technologies" are underlined [1, p.6]. An article by V.S. Gryzlov is worth noticing [2]; it proposes a competence-modular unified model of engineering education. At the same time, one of the aspects of the educational aim is determined as "development of industry-specific functional models of professional activity". A topical issue is the determination of the application area and classification of models in professional education.

Analysis of relevant research and publications

The first example of scientifically grounded application of the simulation method is considered to be the work on researching hydrodynamic characteristics of water carriages in experimental tanks conducted in the latter half of the XIX century [3]. In the first half of the XX century, the term "model" referred not to the science, but to the industry, first of all, to metallurgy and architecture. In the 1940s-1950s, the disciplines of cybernetics, computational mathematics, and programming have rapidly developed. This has determined the need and opportunity for torrid growth of simulation as means for scientific cognition.

Theoretical background of this research is based on the works of V.M. Glushkov [4], V.A. Venikov [5], V.A. Shtoff [6] on the issues of simulation. This article uses the classical definition of the term "model" in the context of theory of knowledge: "Model is a contemplated or a materially realized system, which, while displaying and simulating the subject of research, is able to substitute it in such a way that studying it provides new information on the subject" [6, p.19]. A model is seen as an instrument or a form of cognition.

Author's previous publications propose a classification of models in pedagogical research [7].

This article complements and generalizes author's research on the problem of pedagogical simulation. Definitions of the terms "informational model", "model of a specialist", "model of specialist's training" are proposed in this study.

The aim of the article is to characterize the classification of models used in professional education.

Table 1 provides systematized results of the author's research on models' classification used in professional education, as well as the characteristics of the main model types. Classification is proposed as a result of scientific literature analysis on the problems of pedagogical simulation, cybernetics and systems research.

This research discloses the most valuable classification features of models used in professional education.

Besides the stated above features, each model of professional education can have stable, mastered and time proved, as well as variable elements related to the introduction of new materials, equipment and technologies in industry and education.

Conclusion

As a result of the conducted analysis of scientific publications on the issues of pedagogical simulation, cybernetics and systems research, a classification of models

Table 1. Classification of models in professional education

Class of models	Characteristics
	Application area
Educational models	Used for teaching: models of atomic and molecular structure, prototypes of machines and mechanisms, solution models for textual tasks, etc.
Scientific and research models	Used for conducting scientific research Reporting or conceptual models disclose the state of a system, give an opportunity to determine its components and study their interconnections. These models are suitable for understanding state-of-the-art of systems and set up of research objectives. Research models allow conducting real, as well as imaginary (virtual) experiments. Imitation models replicate the existing features of systems' behavior and allow researching the influence of external factors on systems' performance. They give answers to such types of questions, as 1) what will happen if …?; 2) what was the cause …?; 3) what should be done in order to …?; 4) is the hypothesis … correct?
	Form
Material models	A system materialized in tangible medium, which is compatible with the subject by its geometry, physical, structural or functional characteristics.
Informational models	A system expressed in the language of symbols, signs, images, words, which represents a subject of research and allows to reflect features of the subject essential for the research, as well as to receive new information on the subject.
	Structure
Hierarchical models	Objects are allocated on certain levels; at that, the objects of lower levels serve as components of the upper level ones. The hierarchical principle is used to create classifications and management schemes for educational institutions.

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Class of models	Characteristics
Table-form models	Main subjects and their features are presented in side tables in a listed form. Their qualitative and quantitative characteristics are presented in corresponding table cells. The table form is used to create curriculum models, comparison models, etc.
Network models	Describe systems with a complex structure of elements interaction.
Subject of research	
Model of a specialist	A system that reflects both the input parameters, which have the biggest influence on a specialist (innovation development foresight and others), and the output parameters, i.e. professional and other qualities of a specialist (knowledge, skills, competences).
Model of specialist's training	A system, which reflects a system of future industry-specific specialists' professional training and is capable of replacing it in such a way that studying it provides new information on its interconnected structural elements tentatively joined into blocks: factorial, target-oriented, theoretical and methodological, contextual and technological, result-oriented.
Model of educational means	Models of curricular, programs, guidebooks, visual aids, technical teaching means, laboratory equipment, etc.
Development in time	
Static models	Reflect the state of a system in a particular fixed moment of time Historical models reflect the state of a system in the past. Actual models simulate the current state of a system.
Dynamic models	These models simulate development of systems in a researched period of time. They can be discrete or indiscrete. Discrete ones reflect the state of systems within a number of fixed periods or moments of time. Indiscrete models indicate continuous changes of system's state depending on time. Historically comparative models allow comparing system's state in a certain period of time in the past to its current state. Foresight models reflect state of a system in the future after a certain period of time, taking into account events and processes that have already happened and will affect the system in the future (for instance, modernization of educational equipment requires changes in study programs, books and guidance materials). Prognostic models are created based on research of trends in changing the contents and organization of work, social interaction of future specialists, equipment, materials and technologies they use, as well as trends of societal development (for instance, based on the prognosis described in [8]).

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Class of models	Characteristics
Level of reflection of system's core features	
Principle-based models	Reflect the most essential connections and features of a system [9]
Structural models	Provide a general understanding of the form, location and number of the most essential components, as well as their interconnections
Functional models	Reflect specifics of system's functioning according to its intended purpose. They can be presented in graphic forms, such as block-chains that indicate a set of actions aimed at achieving the result [10, p.79]. These models are widely used for description of complex technological processes.
Parametric models	Mathematical models that allow determining quantitative interactions between systems' parameters.
Level of specification	
Enlarged models	Provide information on most valuable elements of a system and their interconnections. Allow investigating pedagogical systems at large, take strategical decisions on routes and prospects of educational system's development.
Explicit models	Provide thorough information on selected sub-systems
Detailed models	Provide the most detailed information on selected sub-systems and their components
Problem broadness	
International models	Provide information relevant for education as a particular sphere of action.
National models	Provide information relevant for an educational system of a certain country.
Regional models	Provide information relevant for an educational system of a particular region.
Unique models	Provide information relevant for a particular educational institution or structural division.

applied in professional education has been developed. The research discloses the most valuable classification features: application area, form, structure, subject of research, development in time, level of reflection of system's core features, level of specification, problem broadness. The main distinction of the proposed classification from the similar developments lies at the root of the choice of the classification features and the fact that determination of models' classes takes into account the specifics of professional education. Particularly, definitions of the terms "informational model", "model of a specialist", "model of specialist's training" have been developed. The proposed classification of the models applied in professional education serves for the purpose of development of simulation as means of scientific pedagogical research.

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Project-Based Learning and Research at University

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Abstract
The article analyzes the changes in practice-oriented training of stu-dents. It describes the example of making arrangements for enhancing stu-dents' motivation to conduct research and development activities while im-plementing the project within the framework of the Resolution No. 218 of the Government of the Russian Federation.

Key words: higher education, practice-oriented training, cutting tool, 3-D modeling.

The issues related to education modernization have received increasing attention in recent years. Particularly, it concerns training of engineering students, namely, specialists in machine-building industry. It is obvious that the level of knowledge of future engineers, designers, technicians, operators directly affects the future of the country, its economic potential, and independence in the field of up-to-date technologies. The basic problems faced by a modern university are as follows: methodological and technical support of the training process, faculty staff, motivation of students for effective material acquisition.

Lack of students' practical skills gives rise to the intensive criticism both in Russia and abroad [1].

In Soviet times, practical skills were basically developed during summer internships by gaining hands-on experience (fig.1). Education quality at a real workplace is secured by supervisors' interest in new employees, attraction of specialists-tutors from qualified staff of the enterprise and opportunity for students to operate equipment, machinery or motor vehicles. The memories of most experienced specialists about the first working day, the first mistakes and help of elder employees are still alive.

Since 1995 the situation has changed dramatically (fig.2).

Enterprises stop financing student internships, while qualified employees have come to consider interns as their future competitors. Needless to say, that the entire internship was reduced to the formal process: safety induction, excursion, familiarization with documents and goodbye! The interest of supervisors in interns is maintained at the stage of pre-diploma internship placement when the enterprise is striving to get at least some specialists for the opening positions. It is obvious that in this case time has already elapsed as the training process has already finished.

The obvious question arises: what to do? The situation could have been saved by conclusion of a trilateral agreement between university, student, and employer. Such agreement serves as a good motivation for all actors. However, an enterprise should have surplus funds, but it is still insufficient.

One of the powerful tools of a State to enhance the education quality is a State subside in the form of Resolution No. 218 of the Government of the Russian Federation [2]. According to this Resolution, the State should return the funds as a subside spent by the enterprise on research, development, and technological work. The main

Fig. 1. Summer internship of students from Machine-Building University in the 1980s

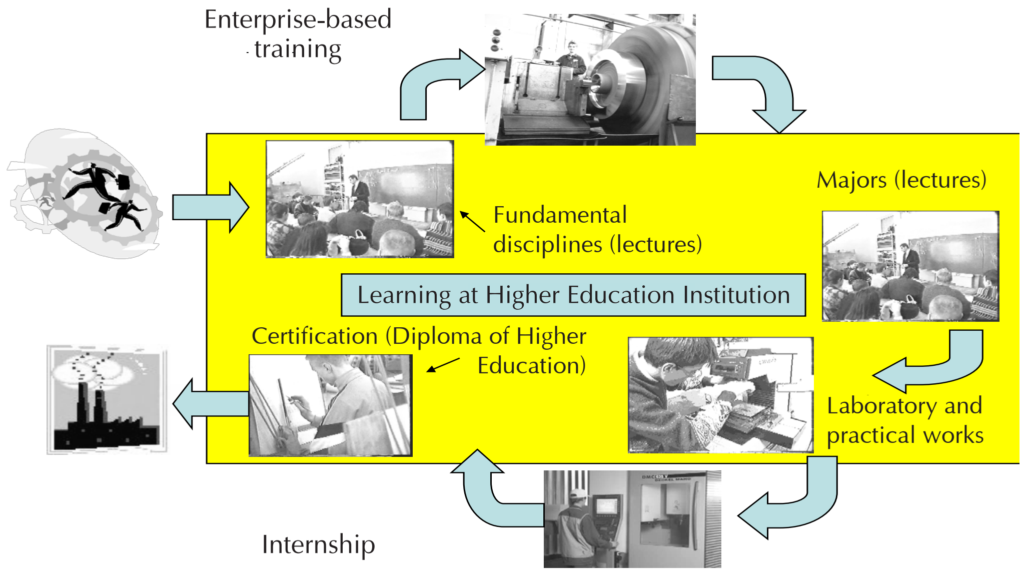
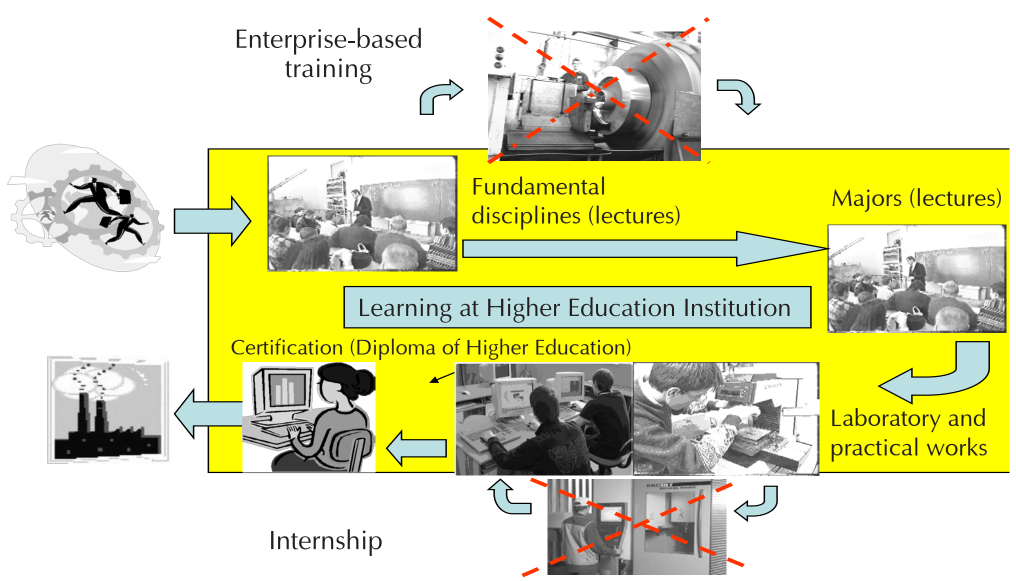


Fig. 2. Summer internship of students from Machine-Building University in the 2000s



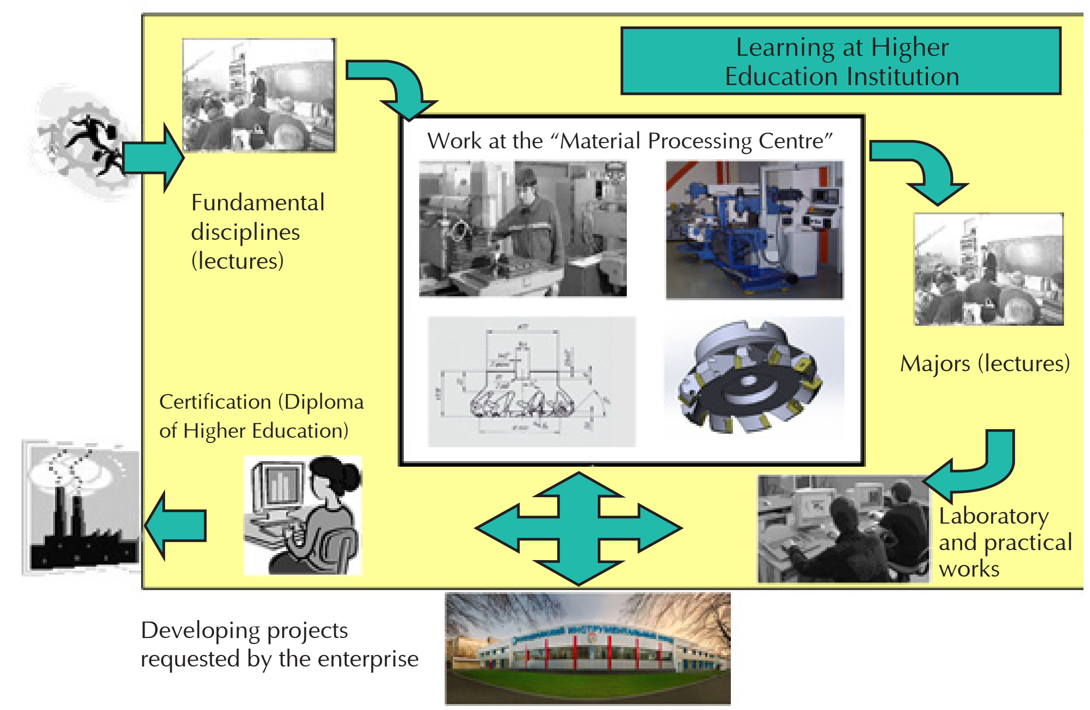
condition is that research, development and technological activities should be performed by students, faculty staff of a university on request of an enterprise. The number of students, young scientists and employees involved in the project is also specified.

As the result of the contest (2015), the project "Development and implementation of innovative industrial technology aimed at manufacturing import-substituting hollow-carrier cutting tool equipped with quick-changeable carbide blades" was recognized as a winner. The project was proposed by Ural Federal University in association with JSC "Sverdlovsk Instrumental Plant". The faculty members of Cutting Machines and Tools Department were the main carriers of the project. Such a large-scale request from the enterprise gave a true meaning to the project part of graduating papers, stimulated students' interest in the conducted research quality. As a result, 14 graduating papers accounted for more than a half of all full-time students' works were defended on the project-related issues. Most graduating papers were performed by students, members of temporal creative group, and the research was paid from additional funds. The laboratory "Material Processing Center" served as a main technological facility where there were all required computer tools and machinery. The project was supported by qualified faculty members. The example of such training process is illustrated in fig.3.

Briefly describing the project, the following characteristics are worth noting:

The main objective of the project is not just to develop a new competitive tool, but to make the arrangement for serial production of this tool including elaboration of the entire technological process, archive and documentation management, recommendations on the effective application of the invention. Thus, it is a comprehensive project, and the corresponding 3-D models, technologies, software and numeric control for each tool type are due to be completed by the

Fig. 3. Training process on the basis of "Material Processing Center" laboratory



beginning of 2018. Therefore, the students involved in the project were divided into the following groups:

- designers of hollow-carrier cutting tool for certain tool types;
- designers of changeable carbide blade archive;
- designers of case processing technologies;
- designers of monitor software;
- future marketing experts;
- designers of e-documents system who are responsible for making connections between interested department of the enterprise, etc.

Such approach is rooted in the CDIO concept "Conceive – Design – Implement – Operate" [3]. It is doubtless that motivation of project participants is much greater than that of the students who are not involved in such projects.

The following graduating papers were defended before the Qualification Commission:

- Design of assembly turning tool on the basis of JSC "Sverdlovsk Instrumental Plant".
- Design automation and analysis of assembly end-milling cutting with changeable carbide blades for production at JSC "Sverdlovsk Instrumental Plant".
- Design automation and analysis of assembly turning tool with changeable carbide blades for production at JSC "Sverdlovsk Instrumental Plant".
- Development of system and pilot unit for metal-cutting oil ingress into the cutting zone on the basis of JSC "Sverdlovsk Instrumental Plant".
- Design of straight-turning tool with indexable inserts for rough and finish turning.
- Design of and technology development for straight-turning tool with indexable inserts for rough turning.
- Automation of spline hob design in SolidWorks environment.
- Development of the archive of carbide blades for turning on the basis of JSC "Sverdlovsk Instrumental Plant".
- Development of technologies for design of parametrized case-based element of spline hob on the basis of JSC "Sverdlovsk Instrumental Plant".
- Design of hollow-carrier cutting tool via typical 3D elements by the example of turning tools produced by JSC "Sverdlovsk Instrumental Plant".
- Design of boring unit with micrometer feed, etc.

The fragments of research results are given in fig.4.

Conclusion

The education programme is considered a main document that secures the logics and quality of students training within the machine-building industry. However, lacking sufficient knowledge of real manufacturing problems and needs, students can hardly focus on the most essential details, i.e. certain parts of lectures, lab problems and practice-related issues, and problem solving methods. Having encountered with a real engineering task, a student could demonstrate the desired readiness for his/her professional activity. Therefore, any interaction of university with an industrial enterprise in terms of solving a real engineering task should be encouraged by state subsidies or funds of sponsors interested in training new manufacturing staff.

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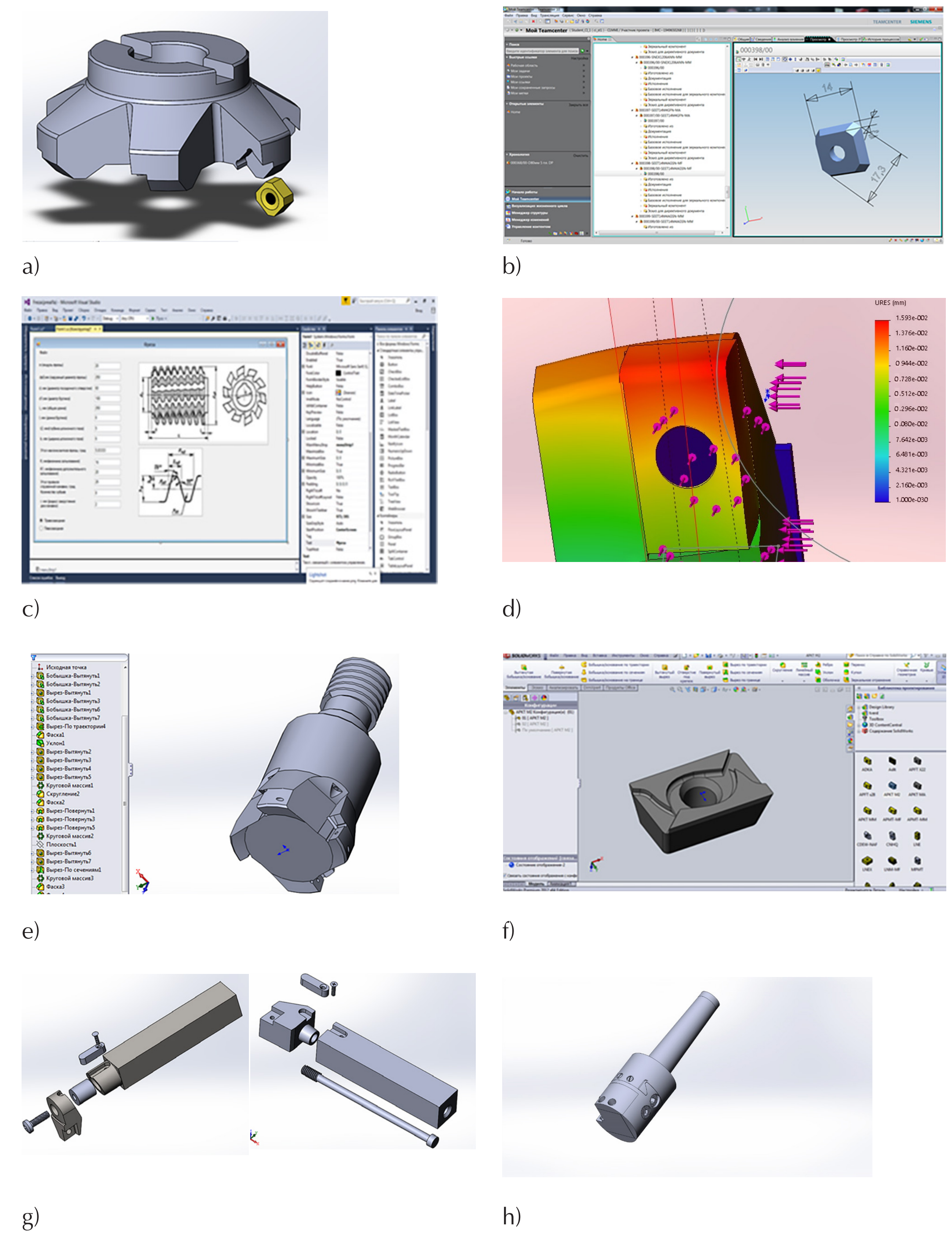
Fig.4. Fragments of students graduating projects
a) turning tool b) STP set for turning tools c) spine module-based hob d) stress analysis of the router bit e) end-milling cutting f). STP set for end-milling cutting g). assembly turning tool h). boring unit



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UDC 378.1

Analysis of FSES Texts of the Last Generations of Engineering Profiles (Speciality "Nuclear Physics and Technologies", Bachelor Degree) in Foreign Language Subject

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Abstract

The article analyzes the Federal State Educational Standards (FSES) of the latest generation by the example of speciality "Nuclear Physics and Technologies", Bachelor degree programme, Foreign language course. The principle changes in the components of the FSES 3 and FSES 3+ standards are considered in the higher education system..

Key words: education modernization, analysis, FSES standards, cross-cultural competencies, professional competencies.

At the moment, engineering education is one of the priorities for the state education policy. The RF Ministry for Education and Science has launched the project "Development of engineering education" which is aimed at modernization of engineering education content, defining the hour amount of engineering staff training structure based on involvement of employers in development of admission quotas, an increase in engineering specialties' prestige.

The concept of the Russian education modernization demonstrates the necessity of education policy and education modernization for effective use: "...Education policy in Russia, reflecting the national interests in the sphere of education and presenting them for the world community, takes into account the general tendencies of the world development conditioning the necessity for essential changes in the education system: significant extension of international cooperation scale, as a result of which communicative and tolerance factors are of prime importance; as there are some global problems that could be solved only via cooperation within the international community" [1].

Modernization of the Russian education in the system of higher professional education is focused on the practical enhancement of 3-level training system (Bachelor – Master – Post-graduate), improvement of education quality, optimization of content and structure of learning process, design of new educational programmes, development of the Federal State Educational Standards (FSES).

FSES is a set of compulsory requirements for basic education programmes of higher education. The HE FSES of the latest generation include the standards of HPE FSES 3 and HE FSES 3+. The Federal State Educational Standards of Higher Professional Education of the 3-d generation were approved as a part of Government Decree of the Russian Federation of 24 February 2009, no.142, the Order of the RF Ministry for Education and Science of 18 January 2010, no. 51 and adopted for implementation in educational institutions in 2011.

Introduction of HPE FSES 3 attracted considerable criticism and debates among the pedagogic community, first of all, because of the great number of a graduate's developed competencies. For example, the speciality 140800 "Nuclear Physics and Technologies" (Bachelor Degree) listed 13 cross-cultural and 31 professional competencies.

At present, the RF Ministry for Education and Science is updating the FSES (information letter of the RF Ministry for Education and Science of 06.07.2016 № AK 1872/05 "On providing materials" due to mainstreaming the HE FSES to consider the requirements of professional standards and needs for development of basic educational programmes of higher education [2].

In 2015 the RF Ministry for Education and Science took the decision of developing HE FSES 3+ according to the Federal Laws of 29 December 2012 no. 273-FZ "On Education" and "On Higher and Postgraduate Vocational Education" of 2012 due to low quality of FSES 3, the great number of competences; technical errors; lack of choice in type (types) of professional activity and, as a consequence, competence clusters; disciplinary structure of the main curriculum, etc.

As a part of FSES projects presented on the site http://fgosvo.ru it is suggested reducing significantly the number of competencies. Cross-cultural competencies are replaced by universal ones (8 competencies) and general professional (3 competencies) for Bachelor curriculum. Besides, the list of a graduate's professional competencies is independently approved by educational institution, "based on the profile of curriculum, taking into account exemplary main curriculum, following the content of generalized job functions (depending completely or partially on the requirements for education and training provided by the professional standard) of the corresponding professional standards (if any) chosen in accordance with point 1.3 of the current HE FSES" [3].

The list of the universal competencies developed in the frame of a foreign language course contains as follows:

- ability to interact (UC-3);
- ability to communicate in business sphere orally and in writing using state and foreign languages (UC-4);
- ability to perceive cultural diversity in social-historical, ethic and philosophical contexts (UC-5) [3, 4].

Mention should be made that these competencies do not only show the tendency towards cross-cultural and social interaction but also demonstrate the ability to communicate in professional sphere.

Analysis of FSES of the latest generation using the profile "Nuclear Physics and Technologies" as an example demonstrates the fact that HE FSES 3+ in comparison with FSES 3 of HPE is distinguished by the essential decrease in competencies for university graduates. FSES 3+ contains 9 cross-cultural competencies, 2 general professional, and 12 professional ones. Besides, according to the Order of the RF Ministry for Education and Science of 12 September, 2013, no.1061 "On adopting the list of profiles and specialities in higher education" the programme of higher education includes two Bachelor degrees – academic and applied. The difference between them consists in different forms of professional activity. The Bachelor curriculum is designed depending on the types of learning activities and requirements for the curriculum outcomes. The curriculum of academic Bachelor degree is focused on research activity, whereas applied Bachelor curriculum is aimed at practice-oriented professional activity. Besides, when designing Bachelor curriculum the new standard implies the extension of graduates' competencies due to the curriculum focus on particular spheres of knowledge and activity. HPE FSES 3 provides the development of all 44 competencies: 13 cross-cultural and 31 professional), without an extension of competence list. In addition, it is necessary to note that HPE FSES 3 include the following list of compulsory disciplines as a basic part of the Bachelor curriculum: history, philosophy, foreign language, health and safety with specification of hours and content, whereas HE FSES 3+ do not provide the number of hours, content, order of delivery for the subjects listed above, as these parameters are defined by an institution independently. Moreover, the institution has the right to establish the subjects of the basic part in terms of the HE FSES requirements.

Hence, we present the comparative table 1 of HPE FSES and HE FSES for the profile "Nuclear Physics and Technologies", Bachelor degree.

As for foreign language course, one can highlight the shift from abilities of mastering foreign language in professional sphere towards communicative competencies.

Thus, according to HPE FSES 3 for Bachelor degree: 050100 Pedagogical education (Physics and information) and 011800 Radiophysics a graduate is to have the following competencies [4, 5]

- ability to master foreign language sufficient to read and understand foreign literature in speciality (CC-13);

Table 1.

Standard component	FSES 3	FSES 3+
Form of study	2: full time, evening classes	3: full time, evening-classes, extramural
Time of study, hours	Full time: 4 years, 240 h. At in-person-remote classes the study period increases 1 year	Full time: 4 years, 240 h. At in-person-remote and remote classes the study period increases not less than 6 months, but not more than 1 year
Types of professional activities	1. Research. 2. Project. 3. Production. 4. Management	1. Research. 2. Project. 3. Management. 4. Installation-setup
Differentiation of Bachelor qualifications	–	Academic and applied Bachelor degrees
The number of competencies	In total: 44 Cross-cultural –13 Professional – 31	In total: 23 Cross-cultural – 9 General professional – 2 Professional – 12
Extension of competencies list	–	An educational institution has the right to extend the number of competences
Educational technologies	–	E-learning, distant education, network of educational programmes
Structure of Bachelor curriculum	Basic part of the curriculum contains a particular list of subjects with specification of hours, content, and delivery order	Basic part of the curriculum contains a list of subjects; the number of hours, content, and delivery order are defined by an institution

- ability to speak one of foreign languages at the level sufficient to obtain and assess information in the sphere of professional activity from the foreign sources (CC-10).

Whereas the current HE FSES 3+ of engineering profiles updated by the Orders of the RF Ministry for Education and Science of 12.03.2015 specify the following cross-cultural competencies:

- ability to communicate orally and in written form in Russian and foreign languages to solve interpersonal and cross-cultural interaction problems (CC-5);
- mastering foreign language at the level sufficient to communicate (CC-12) [6].

As is seen, the main purpose of the foreign language course in engineering universities is to master communicative competence in foreign language for solving communicative problems. Foreign language course at university is of communicative character. Based on the analysis of university education programme one can conclude that as a result of foreign language mastering education engineering programmes, development of cross-cultural competencies (ability to communicate orally and in written form in Russian and foreign languages to solve interpersonal and cross-cultural interaction problems (CC-5); and mastering foreign language at the level sufficient to communicate (CC-12)) was provided.

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UDC 377.5

Pedagogical Conditions for Research-Technical Creative Activity in Technology Training

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Abstract

The article is concerned with the study in the issue of development teachers' creative potentials engaged in students' technology training.

Having analyzed the practice of research-technical creative work, the author shows the dynamics of students' achievements from the fifth to the eleventh form, observes the changes in general awareness of process technology and understanding the essence of these processes and their perspective improvement.

The work defines pedagogical conditions for research-technical creative activity in technology training consisting in the idea of students' special attitude towards labour, development of profile skills and features, such as: civil liability, patriotism, and need for labour activity. The principle aim of this development is to involve students in labour activity based on their in-born individual abilities, to teach them to apply modern scientific achievements.

Studying the dynamics of transforming a student's cognitive interest and the results of research in the sphere of pedagogy, the author justifies a number of concepts stated in the article to provide efficient technology training.

Key words: research-technical creative work; pedagogical conditions; technology training; conditions of creative activity organization.

The basic professional quality of a teacher is considered to be his/her potential ability to participate in teaching research-technical creativity within the framework of technology training. Creative pedagogical activity implies creativity, which is a result of a teacher's personal creative work and his/her creative abilities.

The distinguishing feature of research-technical activity is an effective result. An object of teaching creative activity is a student. The potential teaching creative abilities include not only development of its structural elements, but also establishing potential interactions between the creative elements, identifying uniform factors.

If targeted at qualified specialists' training, the institutions of higher vocational training are required to find the leverage influencing the formation of students' motivation for creative activity.

The classes delivered at the teachers upgrading course do not reveal the formation of interaction among the creative elements or, if so, it is performed inefficiently. The teaching creative experience does not focus teachers' attention on development of creative search skills.

The issues of creative activity organization do not consider the urgent necessity of a teacher's involvement. The lack of some teachers' understanding the essence of teaching the bases of creative activity results in inconsistency between the expected results and existing expectation of society related to the issues of training highly qualified creative specialists. Some educational institutions do not form teachers' positive motivation for research-technical activity. The requirements for teachers' organization of learning cognitive activity do not take into account differentiation of teachers' potentials with different creative skills. No attention is paid to teachers' and students' age peculiarities, teachers' creative experience, and desire to solve this problem[4].

The contemporary education theory is focused on development of integrative conceptual view of the environment. The market requirements do not include the demand for students' creative experience. This situation has led to the necessity of reforming the content of the existing education system.

The concept of teaching a course of technology at secondary school suggests the solution of the urgent problem under the condition of innovative production development, consideration of world experience in the sphere of research-technical creative activity, its application in vocational training. The focus is made on the applied trend of training process. Students are taught to practically applied knowledge of basic concepts of studied disciplines directly in creative activity ensuring the continuity of skills when transferring the next stage of professional education.

The idea of technology creative training is to develop a student's social attitude to labour, mastering professional skills and personal features, such as: civil liability, patriotism, and desire to work [5].

School vocational education is based on study in effective application of new technologies using practical examples. It became a support base to form pupil's individual qualities [3].

The primary objective of such development is to involve students in labour activity with the support on their in-born individual abilities, to teach students to apply contemporary scientific achievements.

The goal of educational institution is to ensure the conditions for mastering practical skills in using all possible transformation methods, taking into account the expected consequences of technogenic production, to teach the techniques of advancing a professional path.

Training is suggested to be focused on the solution of the following problems:

- forming viewpoint, understanding the significance of individual labour, involvement in general labour discipline based on technology requirements;
- creating a technology systematic base, teaching practical experience demanded by modern society covering all spheres of human activity;
- ensuring the conditions of broadening the scope of interests, applying knowledge of creativity acquired within theoretical course in practice;
- developing knowledge including computer skills;
- building on the experience of applying various forms of activities, developing skills including business communication;
- studying the basic elements of economic education including business activity;
- forming information database on existing and perspective jobs and requirements of contemporary labour market;
- fostering patriotism by the examples of Russian specialists' activities in the sphere of new technology implementation and engineering innovation [1].

Given the importance of monitoring the dynamics of changes in a pupil's learning interest, results of pedagogical research to provide efficient technology training, it is based on a number of principles:

- the range extension of technological production methods, study of current scientific and technological level;
- focus of learning process on practical creativity, enhancing visual forms of studying technological methods;
- classification and structuring creative techniques used to solve the problems set in the course of social, team, and individual activities.

The content of training course covers: fragments of production, options of using power and information resources.

In the course of technology training based on introduction of creativity, pupils acquire the following set of skills:

- to reason an individual professional path;
- to find, comprehend, and apply relevant information, correctly perform the functions according to technical requirements;
- to arrange creative activity based on the qualities facilitating production;
- to perform common technological operations observing safety regulations by means of tools, devices, and engineering equipment;
- to search for necessary information sources and use the information to acquire knowledge of operation technology;
- to choose effective and cost-efficient methods of technological process;
- to define an elementary impact of production on environment;
- to make and analyze suggestions of improving technology, update knowledge of business regulations;
- to match the level of his/her own professional skills and inclination for performing some activity, plan his/her life and professional path;
- to work individually, in tandem, in small and large teams [5].

Based on the analysis of pupils' age they were divided into three groups in terms of their development and ability to acquire technology knowledge:

a) Junior group, pupils of the fifth – seventh forms characterized by small scope of technical and professional knowledge, lack of skill to analyze their abilities, absence of skills to search for necessary information, low capacity of operation performance related to product improvement, limited by manual labour skills. The expected results of the given group are development of imitating function, confidence in choosing a profile and definite product, a large number of trials and errors, focus on high performance achievements.

b) Intermediate group, pupils of the eighth and ninth forms characterized by elements of self-esteem, desire to criticize statement of definite problem, refusal of help during his work, desire to work separately from a team, careful approach to profile selection, fear of failure in work performance, formation of manual skills. The expected result is search for an item of production unknown before, search for original technological solution for work performance, strive for success, curiosity.

c) Senior group, pupils of the tenth – eleventh forms characterized by sufficient scope of technical and professional knowledge of production process, ability to apply practical experience for his/her activity, desire to reduce production activity and safe material, challenges in selection of production item, dependence of pupil's opinion on team opinion, possibility of disagreement with problem statement, preference to mental activity over manual one. The expected result: focus on complete understanding of physical and technological processes of labour activity, development of pupils' interest in checking their abilities, striving to personal success[2].

The analysis of research-technical creative practice has shown the dynamics of pupils' development from the fifth to eleventh form, from general knowledge of production technologies to understanding the essence of this process and comprehension of perspective improvement.

The principle forms of technology training include performance of production tasks, search for solution options of problems, doing practical and lab-practical works, planning professional path, performing creative activity influencing the development of creative skills. This process aims at multi-aspect results: all-round development of a pupil's individual qualities, production of actual item as a result of technological activity in the form of particular tangible product.

The content of technology curriculum is focused on developing continuous pupils' demand for technological knowledge and desire for self-education. Technology training should not be a goal, but a condition for learning process radically different from subject-oriented approach realized before. In this case a teacher has to be a technical assistant with organizational and consultant functions in joint labour [3].

The urgency of determining pedagogical conditions for potential application of creative activity in technology training shows the necessity of conducting research in this area.

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UDC 624.04

Experience in Design and Implementation of Educational Software within Strength of Materials and Structural Mechanics Disciplines, TSUAB

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Abstract
The article presents the results of software implementation into education process provided by the department of "Structural Mechanics", TSUAB. These software packages are intended to solve problems in the disciplines "Strength of Materials" and "Structural mechanics". They allow checking the correctness of manual calculations, rapidly finding and eliminating the mis-takes being made, avoiding a great number of typical calculations. The de-veloped software packages are characterized by advanced interface; the ini-tial data are presented in a way that is familiar for students; the software packages are free.

Key words: strength of materials, structural mechanics, educational software, generator of "bending" problems.

Modern higher education could hardly be imagined without application of computing techniques. At civil construction universities, delivery of the disciplines related to material strength issues should be always supported by software LIRA-SAPR, SCAD for civil and structural engineering [1, 2]. Unfortunately, time is always required to examine and properly apply the mentioned and analogous software packages. In most cases, discipline curricula do not include time to study these software tools. In addition, the software packages provide the final calculation results based on the initial data without showing the whole calculation process. This fact impedes stage-by-stage evaluation of students' knowledge. Due to the mentioned facts, a number of universities have developed their own software packages for problem solving within such disciplines as "Strength of materials" and "Structural mechanics" [3–6]. As a rule, these software packages are available only for students of these universities. Mathcad, Microsoft Excel and etc. allow solving only those problems for which solution templates have been preliminary developed [7, 8].

Since 1995, in the Department of Structural Mechanics, TSUAB, free educational software for engineering calculations and graphical design has been developed [9–12, 14–18]. These software packages are aimed at problem solving within certain blocks of the above-mentioned disciplines, therefore, students need little time to familiarize with them; as a rule, for this purpose an educator should show the way initial data are prepared and calculations are done based on the example of one typical problem. All input data are not different from the information studied within the course and graphically shown including sizes, types and location of control network and acting loads.

The main advantage of the software is the possibility to evaluate students' knowledge at each stage. They allow quickly identifying and correcting the mistake in complex problems, for example, at calculating statically indeterminate systems via the force method or displacement approach. Solving a number of problems, for example, when designing a bending line of a beam, calculating three-hinged arch or solving flat stress problem, a student has to do a great number of basic calculations by himself/herself. When applying the developed software, in the case of correct calculations a student is provided with the calculation results in terms of distribution diagrams, deflections, deviation angle, etc. which he/she can apply in further engineering calculations and graphical design. All software packages are designed using Object Pascal programming language in visual environment Borland Delphi 7 [13].

The software "GeomW" [10, c. 3–20, 14, 18] is intended to calculate geometric characteristics of plane cross section (fig. 1). To prepare the initial data, all sections are divided into simple figures: rectangular box, right triangle (left), semi-circumference, quadrant, flanged beam, U-section, equal angle, unequal angle (right, left). For each figure, relevant dimensions, geodetic control network and deviation angle in respect to the initial location are input. The rolled sections are selected from gage materials provided by the software. The geometric characteristics of the entire section are control values and hidden from a user. Incorrectly calculated values are colored. In this case, a student is able to find mistake in calculations checking the values of geometric characteristics of each figure. Formulas for simple figures and gage materials of the rolled sections are given as reference data.

The software "BeamW" [10, pp. 21–29, 18] builds distribution diagrams of bending moments and deviation angles in statistically determined beam (fig. 2). For calculation, the initial parameters method is used. The initial data are as follows: beam length; cross-section coordinates; data on the loads acting on a beam. The control values are reaction of support, bending moments and transverse forces in two selected sections; deflection and deviation angle in one section. The calculation results are given in the software window if the corresponding control values are correctly determined. If necessary, it is possible to check the correctness of initial data determination – deflection and deviation angle at the central point.

AstraWMs" and "AstraWMp" [15, 18] are used by students for engineering calculations and graphical design on the following topics "Calculation of statically indeterminate systems via the force method" and "Calculation of statically indeterminate systems via the displacement approach". A student is provided with an opportunity to check the correctness of manual calculations in terms of building distribution diagrams showing bending moments; calculations of canonical equation coefficients; calculations of indeterminate values; building of final distribution diagrams of internal forces. The software is equipped with a wide range of filters, zooming application, distribution of forces based on the elements, etc. The calculation is rooted in the finite elements method which is a basic one in engineering construction analysis [19].

Software "ArkaW" [10, p. 30–38, 18] allows defining internal forces and reaction of supports in the three-hinged arch (fig. 3). A student manually calculates the bending moment, traverse and longitudinal forces for a control section of the arch; if the results are correct, they are shown on a display screen including data on all sections (table of values, distribution diagrams of internal forces).

Assessment of students' knowledge is an integral component of education (admission tests, current tests, final tests). Software TestW [16] is intended for assessing students' knowledge of the disciplines related to material strength issues and is operated in two regimes (fig. 4). The first regime involves formulation of questions and possible answers. To develop a test, it is required: to provide the title of the discipline;

Fig. 1. Windows of software for calculating geometric characteristics of plane cross sections

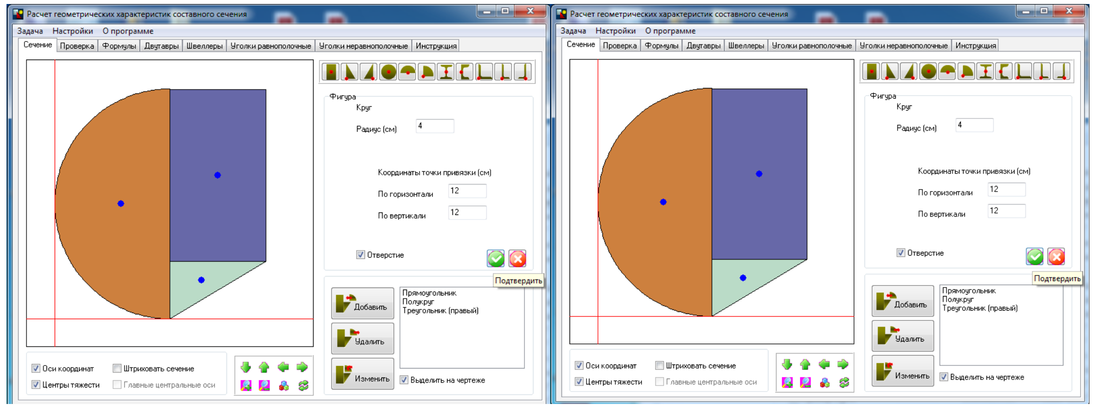


Fig. 2. Windows of the software to calculate beam deflection

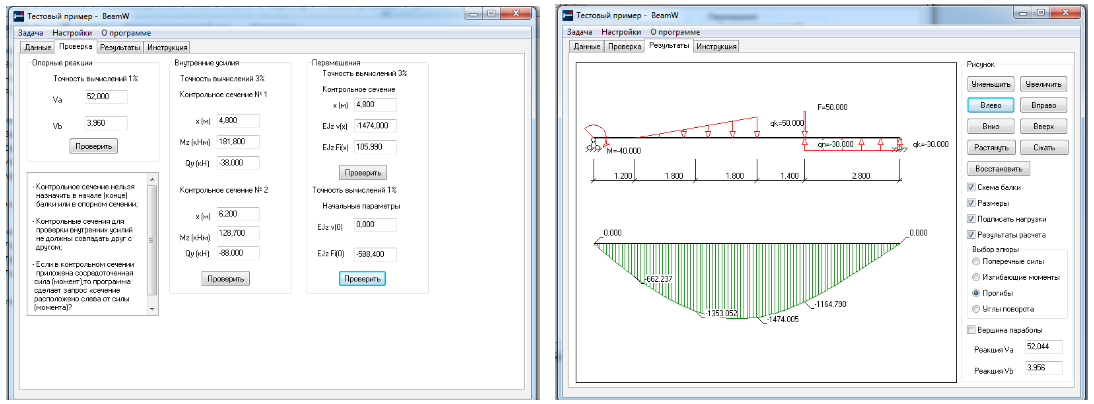
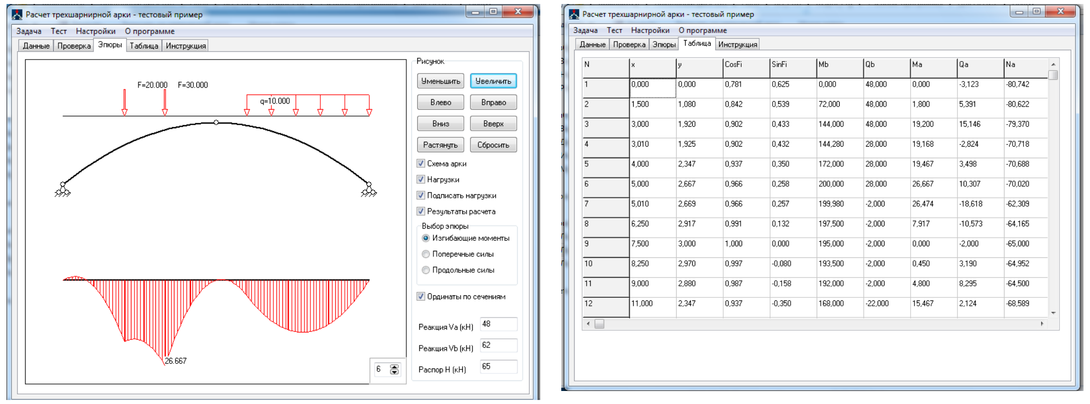


Fig. 3. Windows of software for calculating three-hinged arch



to provide the title of the discipline block and upload the question which has been preliminary saved as PDF file. Depending on the question type, a type of an answer is selected (single selection answer, multiple choice, round figure, real number, word). The software allows editing the question, provides a certain number of points for a correct answer, includes a question into the base (excludes from the base). Knowledge assessment is carried out either within one discipline block or throughout the discipline (in this case the set number of questions is randomly chosen from the question base). To date, the department of Structural Mechanics (TSUAB) has developed the test in the following disciplines: "Engineering Mechanics", "Material Strength", Material Resistance", "Elastic Theory", "Numerical methods for calculating engineering constructions", "Nonlinear problems of structural mechanics".

The software "Beams_frames" [17, 18] allows checking the correctness of calculations of support reaction and internal forces in the statistically determinant beams and frames (fig. 5). The computational algorithm of the software is based on the finite elements method. The bending moments, traverse and longitudinal forces are measured at the beginning and the end of each section. In the case of correct calculations, distribution diagrams of internal forces with characteristic offsets are shown on a display screen. The software provides students with opportunity to create the calculating schemes in two ways: randomly specified by a user or set according to the requirements of engineering calculations and graphical design performed in the Department of Structural Mechanics. In addition, there is a tab where the problems of various difficulty are generated. The initial data in terms of section sizes, places of acting forces and force values are randomly selected. This generator is recommended for independent student work, for instance, training for final certification.

All software packages are registered in the Record of Software Applications and available as EXE files [18]. In addition, software instructions, lectures, presentations, reference books and other teaching aid are available in the website [18].

Many years of experience in application of the developed software packages has revealed the following:

- a sharp decrease in time for search and correction of the mistakes made during manual calculations, which positively affects the training process;
- engineering calculations and graphical design performed via software packages significantly increase the interest of students in the studied discipline, which, in its turn, contributes to better understanding of theoretical knowledge and acquisition of practical skills;
- the developed software packages are particularly useful for e-learning as an effective tool of students' independent work;
- students acquire skills (calculation scheme design, preparation of initial data followed by obligatory monitoring, analysis of obtained results, search for mistakes and their correction) which are necessary for further work with software packages intended for engineering construction calculations during course paper and final paper design.

Fig. 4. Windows of software to design tests and students' knowledge assessment

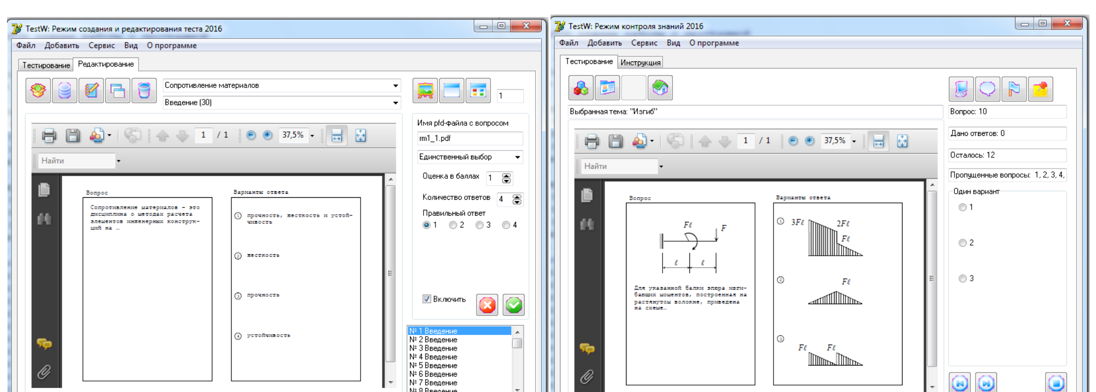
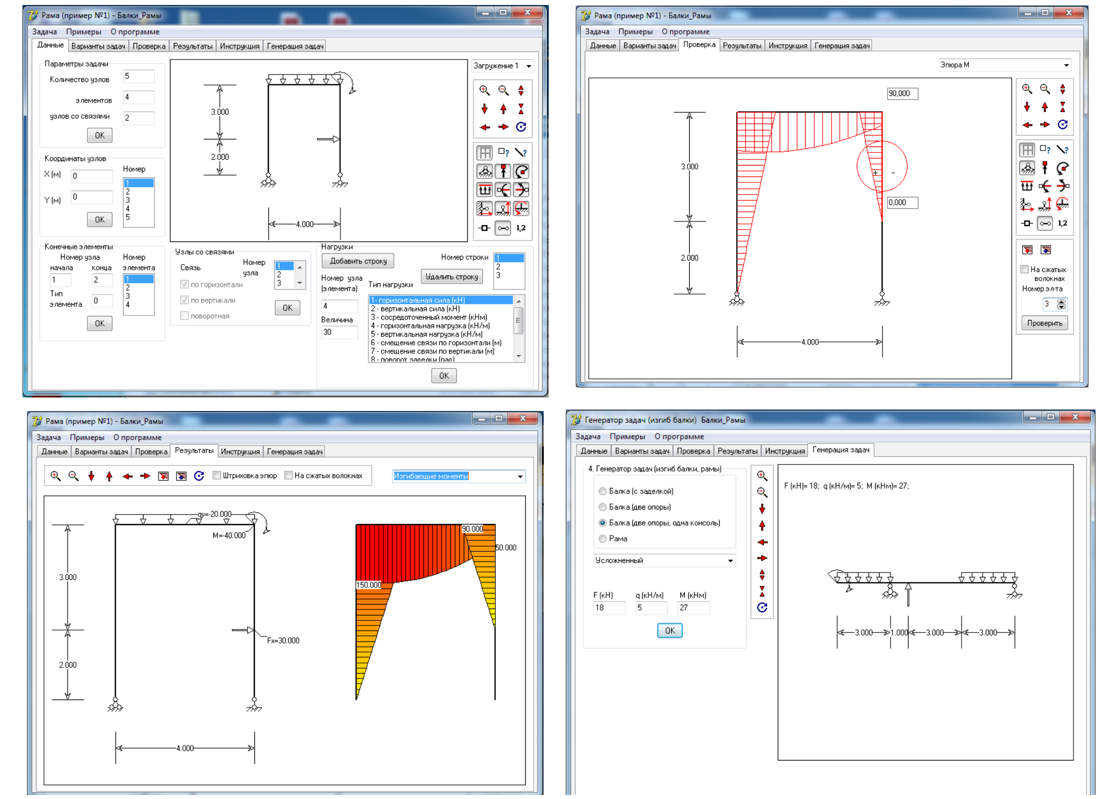


Fig. 5. Windows of software for solving problems of defining internal bending forces



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English for Specific Purpose for Future Engineers: Software Application

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Abstract

The paper studies pedagogical reasons to apply training software and suggests software technology for learning ESP in technical higher schools. The main part of the article is devoted to the particularities of multimedia training course introduced at the first stage of foreign language training, as well as software to test students' ESP skills during further training.

Key words: training software, English for Specific Purpose (ESP), assessment software program, foreign language behavior, foreign language speaking activity, multimedia.

Introduction

The current reforms in Russian higher education are aimed at developing a system that would meet the requirements of modern information society, which implies efficient introduction of information and communication technologies (ICTs) in learning activities.

Article 15 of the Russian Education Act defines e-learning as the implementation of the education programmes via partial or full application of ITs and communication systems including Internet. Universities can use e-learning and distant learning in all their education programmes.

The aim of the article is to examine pedagogical reasons for application of software in foreign language training. In particular, we study multimedia software and e-learning test used in the first year of study and assessment software program based on e-learning that is applied in the frame of ESP courses (second year of study) in a technical higher school.

Theoretical background

One of the obvious advantages of e-learning is the development of students' information culture that is urgent for their future professional activities in the information society. Life-long learning implies the developed skills of "self learning via efficient information processing" [1, p. 193].

Most of ICTs have not been developed for educational purpose; however, ICT application causes great changes in training procedures, forms and methods. Thus, the issues related to ICT didactic characteristics, and methods of its application in learning are of great topicality. It is proved by a great number of research works both in Russia and abroad (A.A. Andreev, N.V. Ivushkina, P.I. Serdyukov, I.E. Grechikhin, S.A. Beshenkov, S.G. Grigor'ev, V.P. Demkin, A.A. Kuznetsov, M.P. Lapchik, S.V. Panyukova, T.S. Feshchenko, I.V. Robert, K. Evelin, B. Oliver, J. Higgins, S. Papert, T. Russel et al.).

A.A. Andreev defines the following types if ICTs applied in learning [2]:

- Training software (electronic courses and manuals, simulators, tutors, laboratory practicum, testing systems).
- Training systems based on multimedia software.
- Intellectual and training expert systems.
- Databases.
- Communication software (e-mail, teleconference, data-exchange networks).
- E-libraries, distributed and centralized publishing systems.

The relevance of multimedia application in NNSTU n.a. R.E. Alekseev is conditioned by the requirements for multi-level training. Most of the training multimedia software ("Focus on Grammar", "Reward", "Talk to me") provide such opportunity.

Individual learning ensured by interactive training form is one of the main advantages of learning in a computer class. Technical and didactical opportunities of the training software provide indirect management of training, and conditions for students to "interiorize" new skills and knowledge while solving language and communicative tasks independently.

In this case, the primary aim of a teacher is to make students understand the purpose of their activity, accept the learning task, and fill it with personal content [3].

Practical part

We use multimedia software "Focus on grammar" [4] to train first-year students. The study focus at this stage is to revise and advance grammar and communicative skills in academic and social communicative situations.

The multimedia course is a part of a training kit and is applied along with the basic set of training books [5; 6]. The educational materials developed by Russian authors are applied in ESP training since they have a number of advantages:

- They are developed with taking into account a culture dialogue principle according to which communicative competence in ESP is developed in learning environment that ensures study of both native and foreign languages and cultures based on comparative analysis [7, p. 21; 8, p. 220].
- They include personally important information that is relevant and clear for Russian students ("My native city", "NNSTU n.a. R.E.Alekseev", "The faculty of marine and flight technologies" etc.).
- They are developed on the basis of authentic textbooks with account for particular language level of the students in a particular technical higher school.
- They take into account students' psychological particularities of foreign language acquisition.

It should be noted that «Focus on grammar» is incorporated in the structure of the ESP course and has content and technological correlations with it, thus, serving as an informational support of the course. This property meets one of the basic methodical requirements reflecting the principle of integrity [9, p.33; 10, p.17].

A teacher has the leading role in learning management and uses software as a part of a particular technology. The options of the training software provide a teacher with indirect management that can be implemented in the following ways [11, p. 31]

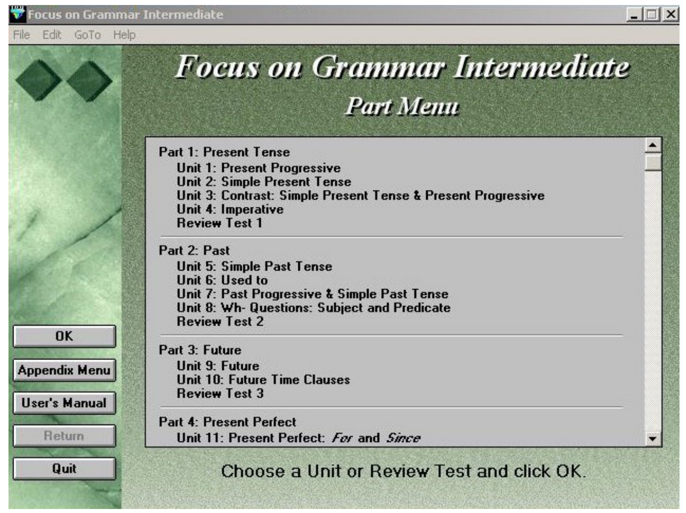
- Content of learning activity.
- System of tasks and exercises.
- Messages of the system as a feedback to students' activity, questions and comments.
- Recommendations related to task fulfillment and mistake correction.
- Assessment (formal or informal).

The course consists of different parts that offer various exercises focused on grammar, listening, reading or writing. Independent learning is aimed at developing key competencies in the structure of ESP communicative competence.

One of the functions of the training course «Focus on grammar» is indirect management of learning activity in the process of grammar training. A wide scope of grammar modules allows practicing grammar not only for general English but also for ESP learning (the second year).

The interaction between the courses (the basic and computer ones) allows choosing the exercises aimed at particular learning objectives. For example, it is recommended to train Continuous tense forms by studying paragraph 3 and 7. (Fig. 1) [4].

Fig. 1. Scope of grammatical exercises



The menu "Recognize" "Identify", "Practice A/B/C/D/E/F" in the part "Discover the grammar" provides the opportunity to choose automated exercises of different levels.

To understand and drill grammar material, it is recommended to do a number of simple tasks focused on identification and choice of a correct grammar form (menu "Recognize" "Identify") (Fig. 2) [4]. To make the grammar skills automated, it is advisable to perform more difficult tasks aimed at correct use of the particular grammar form in a particular context (menu "Practice") (Fig. 3) [4].

It should be noted that "human-computer dialogue" involves students in active learning. Task fulfillment, immediate computer's assessment of the student's answer, and further recommendation require continuous subjective efforts. The visual design contributes to efficient learning as well (Fig. 2, 3) [4].

To ensure formative assessment of grammar skills, it is recommended to apply e-learning tests. Teachers compose and upgrade tasks with multiple choice and open-ended tasks via the tools "Tasks".

Table 1 shows the ways to apply training software and e-learning tests in grammar training.

The training software «Focus on Grammar» can ensure intensive learning aimed at developing listening and reading skills. It is possible to choose some particular speech samples in the frame of social and cultural topics ("Me and my environment", "Way of life", "City. Transport. Urbanization").

Menus "Focus", "Recall", "Guided dictation" in part "Listen" provide students with the choice of automated exercises of various difficulty levels.

To train general reading comprehension, it is advisable to practice simple tasks aimed at identification and choice of the main facts mentioned in the text (menu "Focus") (Fig. 4) [4]. Further, it is reasonable to practice more complicated tasks implying paying reader's attention to details (specific information) related to the main facts (menu "Recall") (Fig. 5). "Guided dictation" offers open-ended tasks [4].

The advantage of the software is elaborated feedback element that serves as a means of individual pedagogical feedback. The system always helps in case of any difficulty. If the answers are incorrect/insufficient, a student will see a relevant message. A student can listen to the text as many times as he/she needs. If it is necessary, the student can address the menu "Help" and "Answer" (Fig. 4, 5) [4].

Fig. 2. Grammar tasks with multiple choice

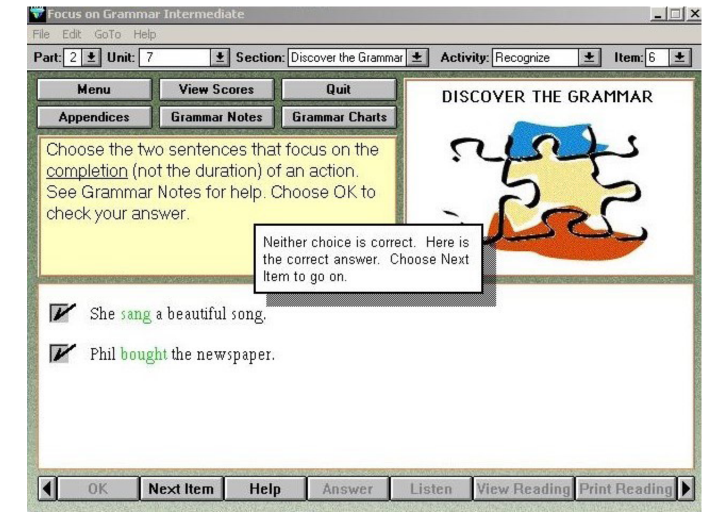
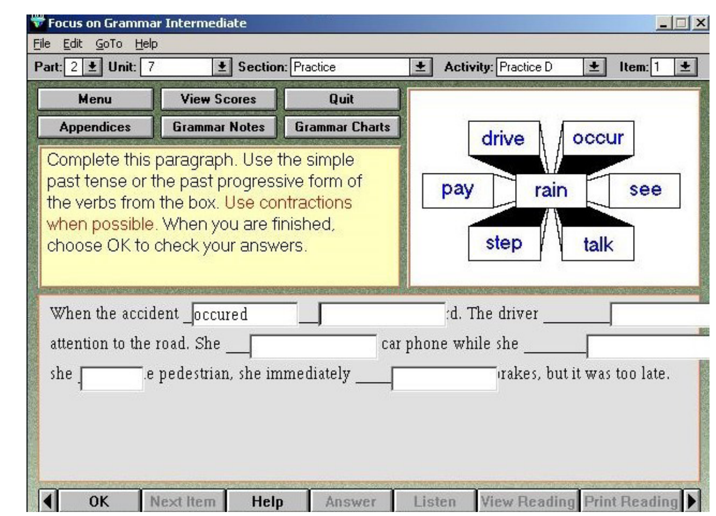


Fig. 3. Grammar open-ended tasks



E-learning provides students with independency and allows them to work at any convenient time. Such system enhances open-mildness to indirect management and students' reflection. Students become subjects of learning activity, its active initiators and controllers.

Table 2 presents the ways to use multimedia software for listening/reading training.

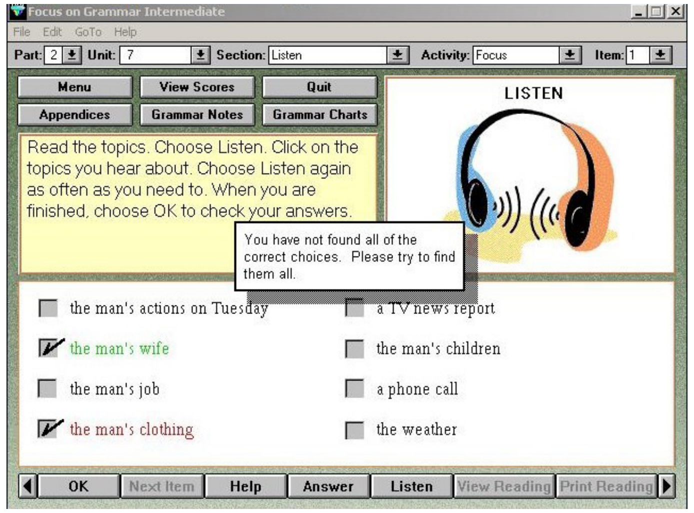
It should be noted that listening and reading of the information (text) related to a particular module can be performed not only during the module study, but also after it. In this case, the learning material is acquired and language skills are developed simultaneously with the personality development.

The assessment software program is used because it meets the goals of ESP training at a particular training stage for particular students.

Table 1. Software in grammar training

Stages of grammar practice	Teacher's activity	Students' activity
1. Introduction and practice of a grammatical form	Explains grammar form or material (tense forms). Gives tasks for primary understanding and use of the grammar form	Perceive grammar material (basic characteristics and markers). Perform the tasks aimed at primary understanding and use of the grammar form
2. Enhancement and drilling of grammar forms	Manages independent learning (IL) via software aimed at developing particular grammar skills	Perform software tasks aimed at recognition, construction and use of a particular grammar form
3. Testing and assessing grammar skills	Provides e-learning tests to assess the level of grammar acquisition	Perform tests in e-learning environment

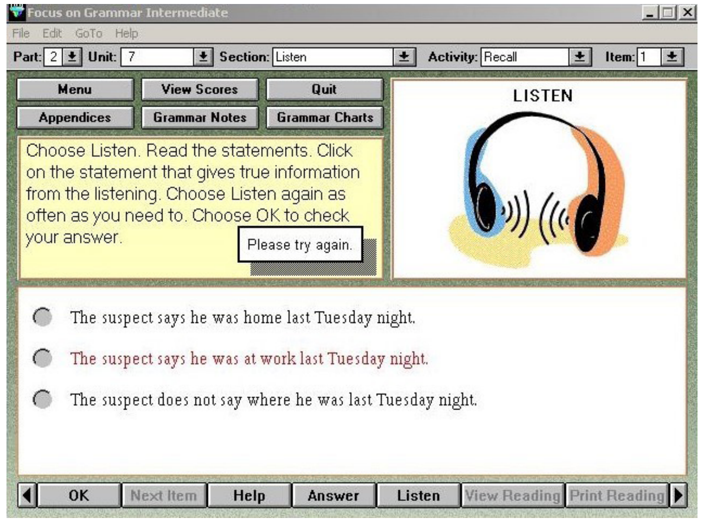
Fig. 4. Tasks to identify general content



It is applied to assess learning outcomes of the students in the frame of particular sphere of professional communication. As V.V. Rubtzov notes, "a computer does not dictate training methods and content, but it can be properly and efficiently included in training programmes to ensure adequate management of learning activities" [10, p. 10].

The second year of language training (ESP stage, 2nd year of study) is aimed at learning terminology and developing the ability to work with the information related to professional activity (in this case – "aircraft engineering"). The choice and arrangement of the incoming information (vocabulary) are carried out with account of interdisciplinary relations of the foreign language and the disciplines related to the future professional activity ("Airplane (helicopter) design", "Machinery systems", "Flight dynamics",

Fig. 5. Identification and choice of more detailed information



Aircraft armament" etc.). The programme also involves "Business English" training.

To arrange the assessment of ESP learning outcomes, it is reasonable to apply the training software for reading and vocabulary oriented tasks. The formative assessment in the form of automated tests relieves teachers from routine activities.

We must admit that development of an efficient assessment software program is labour consuming and requires cooperative work of teaching staff and computer experts. However, one software program can operate several different data selections, and the teaching staff can independently change and update the varied information to meet particular training goals.

A complex of automated tasks aimed at assessment of reading comprehension ensures indirect management of language activities related to comprehension of specific professional information.

The assessment software program identifies the input answers, counts scores and assesses the learning outcomes related to reading comprehension of specific technical texts. It allows assessing learning outcomes of each student efficiently and in an objective way.

The assessment tasks for reading comprehension, as well as tasks for self-control, should be arranged from simple to the most difficult ones.

Generally, the tasks imply identification, choice and reconstruction of the most general, key and detailed information of the text. For example:

- choice of the objects described in the text;
- choice of the statements related to the content (True/false statements) (key information analysis);
- matching of the sentence parts (cross choice);
- reconstruction of the text with the help of the word list (analysis of the detailed information) (Fig. 6).

To assess the terminology acquisition by means of the assessment software program, it is reasonable to offer tasks with multiple choice and open-ended tasks. For example:

- to choose the terms that do not relate to the topic;
- to choose the English terminology equivalents to the Russian ones (possibly in context, or cross choice) (Fig. 7);
- to translate terms from English into Russian.

It should be noted that the automated tasks can be used both for assessment and training activities with self-control. The only difference is in the particularity of the

Table 2. Multimedia software for listening/reading activities in module study

Stages of module study	Aim of learning activity	Teacher's activity	Students' activity
1. Introduction and drilling of new vocabulary.	Language competence development.	Organizes introduction and drilling of active vocabulary of the module.	Practice tasks and exercises for automatic use of the vocabulary.
2. "Immersion" in communicative situation in the frame of the module.	Development of language, communicative and discourse competences.	Ensures practice with basic speech samples and primary drilling of vocabulary in the corresponding context.	Practice basic speech samples, do the tasks involving different kinds of reading (comprehension of social and cultural texts) in written and oral forms.
3. Practice activity.	Further development of language, communicative and discourse competences.	Ensures and manages independent learning via software – simulators aimed at developing listening and reading skills in communicative environment.	Do automated listening/reading tasks in the mode of "human-computer dialogue".
4. Testing and assessment activities.	Further development of all key communicative competences in the frame of ESP.	Provides and manages tasks in speaking, writing and reading via problem-oriented, project and creative training methods as well as forms of control.	Do the tasks in the frame of traditional, problem-oriented, project and creative activities : - report (written or orally); - presentation; - participation in communication, role playing/business game etc.

Fig. 6. Task on text reconstruction

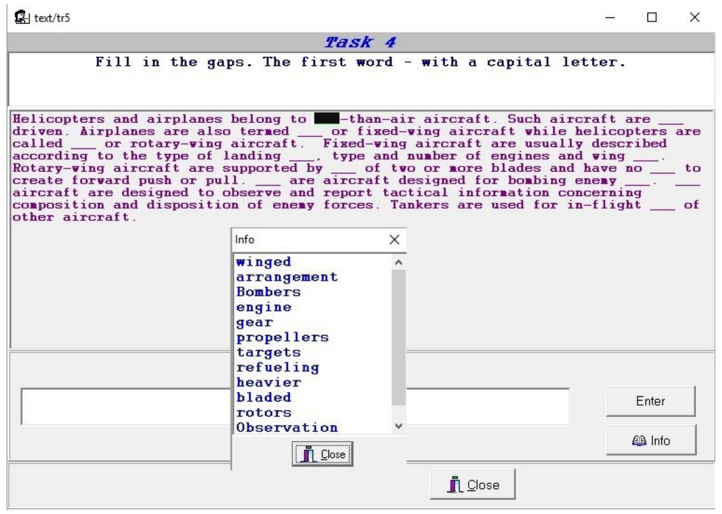
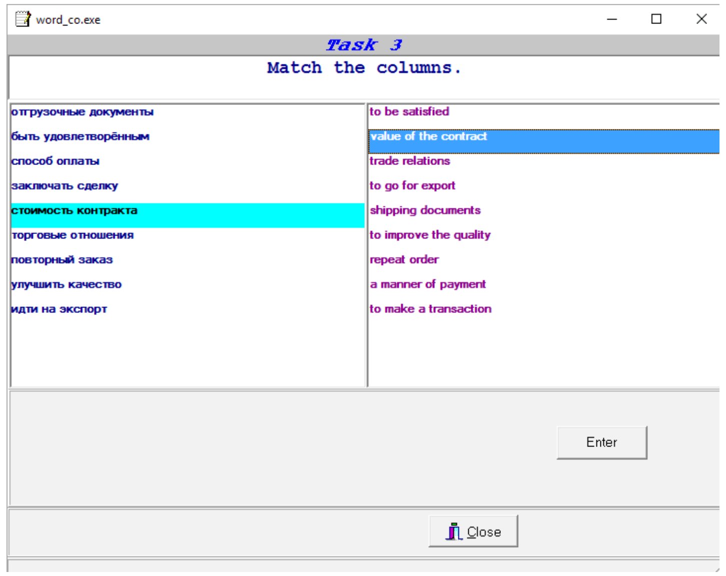


Fig. 7. Tasks to assess knowledge of professional terminology



feedback. The training program implies immediate feedback (simple or detailed), while the assessment mode implies delayed response obtained after a student finishes the whole test.

It is possible to develop such assessment tasks in E-learning environment. However, in this case the tasks have a number of specific features:

- they can be applied in distant (not class room) training;
- they have some disadvantages if compared to the assessment software programs in terms of screen presentation of the material;
- they have limited feedback modes (only delayed).

Table 3 presents the ways to apply the assessment software programs at the stage of ESP training.

The use of software programs for ESP training undoubtedly contributes to students' motivation for ESP learning. Didactical properties of a training software program ensure comfortable conditions for independent language learning activities, which has a positive impact on language skills development.

Conclusion

The theoretical and practical value of the article is justification and examination of training software application in ESP training, which can be useful for foreign language training at any technical higher school.

Table 3. The application of assessment software programs in ESP training

Stages of module study	Aim of learning activity	Teacher's activity	Students' activity
1. Introduction and drilling of new terminology.	Development of language competences.	Ensures drilling of terminology in the context of the module.	Do the tasks and exercises aimed at primary introduction of vocabulary and eliminating language difficulty while reading ESP text.
2. Uptake of content related to ESP module.	Further development of language, communicative and discourse competences.	Provides languages activities aimed at conceiving, drilling of terminology and language pattern in the frame of particular topic in various forms of speech.	Work with the information, do the reading and listening tasks aimed at analyzing and selecting required information in written and oral forms.
3. Testing and assessment activities.	Further development of all key communicative competences in the frame of ESP.	Assesses students' learning outcomes in the frame of the studied module via assessment software programs, writing tasks, and communication in professional environment.	Do the tasks in the frame of traditional and computer testing: - Computer tests aimed at assessing students' comprehension of information and terminology related to the studied topic; Communication and business game; Writing tasks.

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UDC 53

Students' Training in Doing Laboratory Works on Physics

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Abstract

Based on the analysis of advantages and disadvantages of laboratory training methods on physics, personal practical experience, the article describes and justifies intensification of students' training at engineering university in physics laboratory in terms of problem-based approach. The feasibility of specially selected and developed tasks and problems is shown at the specified stages, interactive models, which improves the learning outcomes.

Key words: laboratory work on physics, methods of students' training, interactive models, objectives and tasks.

The general physics course is a basic discipline for future specialists of engineering profiles, without which it is impossible to be a competent engineer who meets modern requirements. Besides, physics is a subject with maximal capacities of developing not only professional, but also personal characteristics of future engineers and, what is more, scientific thinking, which is universal, tightly associated with creativity, and provides reliability of results in any sphere. Therefore, this subject should be paid special attention in engineering students' training.

When training physics at university the following forms are used: lecture, seminar, practical class, laboratory work, student independent work. In addition, physics learning is closely connected with physics experiment both for demonstration and laboratory work. A special place in Bachelor, Specialist and Master training is given to the laboratory physics practice. Physics practice is an integral part of physics course and plays a key role in teaching students the experimental bases of physical laws, phenomena, and processes, developing self-study and experimental skills.

Among the principle teaching goals of laboratory work are:

- observation, experimental evidence, and verification of theory (laws, relations);
- determination of physical constants, substance characteristics and processes;
- study in structure and operation of physical facilities.

The key role of experiment in physics teaching methods has been proved by numerous both domestic and foreign researchers [1-4].

The lab work develops experimental skills and abilities, effectively solves the problem of integrating knowledge, universal intellectual and practical skills and abilities, forms students' professional and personal qualities such as activity, independence, tidiness, analytical thinking, transfer of acquired skills into new situations, etc.

The most common method of laboratory work on physics is students' regular performance of lab works. Groups consisting of, as a rule, two students perform lab works of different content, but of the same theme according to teacher's schedule. However, in this case there appear some challenges, such as: the themes of lab works do not usually coincide with previous topics studied by the students; joint work performance makes monitoring of each student's independent work difficult.

Among the most essential disadvantages of first-year students' preparation for efficient work in physics laboratory are insufficient level of their experimental skills and abilities. Among the reasons is an imitating character of making teaching experiment in physics class at school consisting in measurements and calculations using formulas and detailed descriptions. A formal approach is often used in lab work performance at university as well, when the focus is made on teacher's requirement to submit a carefully designed report on lab work in time presenting the results similar to those calculated by the teacher.

As practice shows, a traditional method of lab classes at university using laboratory operation manuals results in the situation when a student strictly following the manual can perform a lab work without understanding either the essence of performed experiment or physics in general. The challenges mentioned above are exacerbated by a current sharp reduction of class room hours of learning physics at university including lab work hours.

The solution is possible in searching for and practical introduction of new approaches to organization and delivery of general physics labs.

For example, Yu.F. Sviredenko, V.P. Kuntsov, N.N. Martynich have applied a problem-based method in lab classes. In this case they do some preparatory work with students giving them the rules of team thinking work, split the students into subgroups for initial problem discussion, and involve all students into discussion of the problem [5].

When arranging such physics lab class, students are given only problems, whereas the ways of their solutions they find independently passing all research stages – unit assembly, measurement, result processing, etc. However, this method can be used in this form only in independent work of high-achieving students, while the elements of this method are to be taught for all students. For example, the tasks can be as follows: to determine possible ways of indirect measuring some magnitude, define the needed devices measuring techniques independently.

As an essential drawback of teaching physics at university the researchers have noted the inconsistency of lectures, classes, and lab works [6]. V.V. Svetozarov, Yu.V. Svetozarov proposed the technique which eliminated this drawback. It was based on the so-called complex class, at which study of theory is combined with lab works as a single cycle. To deliver such classes, the authors suggested using hours of seminars and lab works together, while lectures were to be delivered as usual. At the complex class, theory is taught in the form of reviewing, monitoring, and enhancing knowledge. Experiment is included in the class to put forward a hypothesis, observe physical phenomena and processes, and support laws. It is made in combination with theory and solution of physical problems. With all obvious advantages of this method, there are some disadvantages, among which is unsuitability of most lab rooms for complex classes. Among the drawbacks the authors themselves noted: the lack of seating capacity, low monitoring of students' readiness for classes, need for joint work at one unit that results in the situation when a more active student reduces other students' initiative [6].

The combination of lab work and classes is proposed as a basis for lab practice by V.S. Zvonov, A.S. Polyakov, V.N. Skrebov, A.I. Trubilko. These combined classes are delivered after a lecture course on definite physics section. The length of this class is six hours, therefore, students have an opportunity to learn independently, as there is no time lag between giving, performance, and control of the task, students' work become individualized, there is a shift from instructive teaching to activity-based approach [7].

We think, special attention should be paid to research in different aspects of using problems at lab works [7, 8, 9]. For example, K.P. Kortnev and N.N. Shusharina propose a method, in which in addition to theory study and lab work instruction a student is to solve several individually selected problems at the preparatory stage. The problems are of research character and selected with the aim to prepare a student for solving experimental problem related to this lab work.

In authors' opinion, this method allows the reduction of existing gap between problem solution and lab work as well as development of students' research skills. Before the lab work, a student is suggested to solve three problems:

- the first problem is given with relatively standard condition, introducing a concept of object, its properties, i.e. a model that is further used in the lab work;
- the second problem is of higher complexity level and it occupies an intermediate position between training and creative problems;
- the third problem is the most complicated as it is of creative character. Its solution smoothly progresses to experimental research made within the lab work [9].

Hence, modeling physical processes, which is performed in solving problems, a student goes to experimental research, where he/she practically checks the validity of modelled concepts and reveals the relations among physical phenomena, magnitudes, and parameters. However, solution of theoretical problems in the course of lab work takes time scheduled for experimental work, which is unacceptable due to the lack of class hours assigned for lab works.

One can identify the most common framework of lab works on physics consisting of four stages: preliminary preparation; making experiment; brief report including experimental result processing, error estimation, records of results and conclusions; submission of lab work.

Ye.V. Yermakova developed the method of lab work performance on general physics based on a problem including support problem as a means of enhancing knowledge, its choice, place, and function at the lab works. In addition, the structure of methodical description is developed for the lab works using the problems [10].

The support problems are problems focused on understanding the essence of lab work close as much as possible to the real practice at lab classes. These are problems, the solution of which reveals some physical meaning of the objects, phenomena (processes) of lab work, their interconnection and interaction.

Taking into account that students' lab activity consists of four main actions, the support problems can be divided into the following basic groups: tasks of preliminary preparation for a lab work, problems for making experiment; task of processing results; control problems and self-control problems [9].

Among the tasks of preliminary preparation: problems showing an approach to a study phenomenon, helping to understand the study regulations; problems of reproduction or determination of calculation formula; problems explaining the phenomena and processes occurred in the study. It means that qualitative or simple calculation problems do not take much time at the classes and they can be solved by a student independently at home when preparing for classes.

Based on the methodical literature, our own research and working experience, it is possible to state a noticeable increase in students' learning outcomes on physics lab work based on the system use of problem-based approach to training and performance of lab works. This work is to start from the introductory lesson. Considering the elements of the error theory, the students are proposed specially developed tasks on mastering methods of absolute error calculation, correct answer record, chart reading [11]. At the next classes there is a measurement practical course where the whole set of practical skills is developed and students are suggested to solve problems of different complexity. For example, determine the body density using a caliper and scales (students are given a body of regular geometrical forms from different materials). The support problems of preliminary preparation for lab works as well as control and self-control problems [11] are to be solved by the students independently at the stage of work preparation and submission, which allows managing class time effectively.

Let us give examples of tasks and problems used for preparation, performance, and submission of lab work "Determination of air heat capacity relations using Clement-Desormes method".

At the preparatory stage:

1. What is adiabatic process? Give examples.

2. What is a degree of freedom? What are they? What does the number of gas molecules depend on?

3. Write down and comment upon Poisson equation. How is adiabatic index determined in terms of heat capacity? In terms of the number of freedom degrees? In this work?

4. What does Clement-Desormes method consist of? What is its essence?

5. What is air? What should air adiabatic index be in standard conditions?

Problems for making experiment:

1. What impact does the balloon volume have on adiabatic index?

2. Why is not h1 set just after pumping air in the balloon?

At the result possessing stage:

1. What are the reasons for deviation of an experimental value of adiabatic index from a theoretical one? What is physical mechanism of these reasons?

Control and self-control problems:

1. What should the γ relation of argon, nitrogen, carbon based the classical theory?

2. Calculate: specific heat capacities of gas mixtures consisting of 10 g of hydrogen and 14 g nitrogen; adiabatic index of gas mixture containing 8 g of helium and 2 g of hydrogen.

3. In standard conditions some gas has specific volume 0,7m^3/kg. Determine specific heat capacities of this gas. What is this gas?

Computers also give ample opportunities in making lab experiment.

From personal working experience we can state that in order to get better learning outcomes, a practical lab work on definite sections of physics is preferably added with computer modelling of those lab works, which performance is either hard in real time or requires modelling for better understanding of physical processes (electromagnetism, concepts of quantum, atomic, and nuclear physics). It should be underlined that they should be only added but not replaced by modelling. Though there are some investigations, where higher students learning outcomes are presented with the use of computer modelling as compared with the students using only lab equipment to solve the same experimental problems [12], one may not refuse the true experiment in favor of virtual one. Students have to work with actual physical devices, assemble experimental units, and use measuring equipment.

It is useful to add interactive computer models to the lab work as such models often allow adequate visibility of complicated physical phenomena and processes, which is impossible when using standard lab equipment.

The most useful are dynamic interactive models, as they support most of essential research stages. They can be used to [13]:

- observe, classify, and generalize the facts including similarities and regularities of the results;
- interpret data;
- explain the observed phenomena and put forward hypothesis;
- design a model experiment to verify hypothesis and make it;
- make conclusion based on performed experiment.

It is possible to highlight dynamic interactive models intended for demonstration, research, design, interactive training units, and interactive problems. The whole range of interactive models in all basic sections of physics is included in interactive source book with multimedia support of physics classes [14] that is widely used by students at all forms of learning (lectures, practical classes, and lab works) and upper class students of secondary school.

In addition, electronic teaching package "Lab work on physics" was developed and successfully used [11]. The package includes two electronic manuals, where there are descriptions of lab works and guidance of their performance in all basic sections of general physics course, which are used at Yurga Technological Institute, TPU. Every lab work consists of tasks and problems divided into units: Unit I. Questions and support problems at the preparatory stage. Unit II. Questions and support problems at the stage of making experiment and result processing. Unit III. Questions and problems for control and self-control.

Besides, the package contains: lectures on the entire physics course; guidebook; interactive multimedia support materials of lab works (interactive figures, models, lab stands); virtual lab works to monitor and develop the basic experimental skills and abilities.

All teaching materials of this package were thoroughly reviewed: they include context menu, active links in the content and integrated into electronic shells. The following software was used: iSpring 7, Adobe Acrobat XI Pro, FlippingBook Publisher Professional, AutoPlay Menu Builder, etc. The given technical solutions provide usability in classroom and at home, sufficiently save time to follow the needed link, find necessary information, print any part of resource and use it in paper form. To use the package resources, interactive models in particular, it is not necessary to connect a computer to Internet, which is very important.

The described method of preparing and doing lab works is a part of students' training in physics based on forward-looking independent work, including the method of students' active cognitive activity at the physics lectures [15], method of teaching students to solve problems on physics in terms of activity-based approach [16, 17].

To assess the efficiency of lab works, the students of experimental (48 students) and reference group (60 students) were distributed into three levels of knowledge and skills to design and make experiment and process the results. For this purpose, we used tests and interview, for which teachers not teaching these groups were involved. To process the results of experiment, the criterion application method developed by K. Pearson was used χ^2 [18]. At the initial stage $\chi^2_н$ = 0,244. At the significance level α=0,05 the critical value of freedom degrees L-1=2 is equal to $\chi^2_{кр}$ = 5,99. It means that students have the same level of knowledge and skills at the beginning of experiment (Table 1).

At the final stage (at the end of the second term of learning physics) students of experimental groups showed higher results $\chi^2_к$ = 7,81 at $\chi^2_{кр}$ = 5,99 that makes us accept the method described above as more effective as compared with the traditional one.

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Table1. Distribution of students in reference and experimental groups in terms of knowledge and skill levels

Levels	The number of students at the initial stage		The number of students at the final stage	
	Reference group	Experimental group	Reference group	Experimental group
1	16	12	15	4
2	31	27	33	25
3	13	9	12	19

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UDC 378.4

Analyzing Employment of HEI Graduates According to the Enlarged Groups of Specialties

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Abstract
The article analyses indicators of Saint Petersburg HEIs graduates’ employment according to the enlarged groups of specialties. The research allows determining groups of specialties with highest graduates’ employment rate, as well as to allocate HEIs according to their graduates’ employment rate within each enlarged group of specialties.

Key words: HEI graduates, employment rate, average salary, enlarged groups of specialties.

Methods for analysis of HEI graduates’ employment

The analysis of young specialists’ – HEI graduates’ employment is topical and particularly essential both for HEIs and for the whole country. Today, the most complete and trustworthy source for HEI graduates’ employment evaluation in Russian Federation is the Portal for monitoring graduates’ employment (based on the statistics of the Pension Fund of the Russian Federation) [1]. The key indicators for evaluating young specialists’ employment on the Portal are the percent of employed graduates and their average salary. Portal’s navigation system allows analyzing data by the constituent entities of the Russian Federation, by educational organizations, by specialties and majors.

The data for this monitoring is provided by the Pension Fund of the Russian Federation, the Federal Service for Supervision in Education and Science and educational organizations. The result of the third monitoring of graduates’ employment is the processed data on more than 1.267.000 graduates of the year 2015 determined by their employment data from 2016 [2]. Thus, the information on graduates’ employment is provided with free access with a 2-year lag: the first year is dedicated to the monitoring itself – the data on pension contributions from graduates’ salaries is analyzed; the second year is for data processing and presentation on the Portal.

Based on the data from the Portal for monitoring of graduates’ employment Saint Petersburg Electrotechnical University “LETI” has initiated a comparative research on the employment of young specialists of Saint Petersburg on a number of the most widespread enlarged groups of specialties. In light of this, the research group has studied data on the employment of graduates of 15 groups of specialties from 21 university of Saint Petersburg. Criteria for choosing the most widespread enlarged groups of specialties of Saint Petersburg to be included in the study were the following: at least 5 universities provide majors in this enlarged group of specialties, and each HEI provides at least 25 graduates within this group.

Table 1 provides information on the enlarged groups of specialties included in the study: codes and titles of the enlarged groups, number of Saint Petersburg HEIs that had at least 25 graduates of these groups of specialties in 2015.

Codes listed in the table correspond to the approved list of specialties and majors of the higher education [3].

Table 1. Enlarged groups of specialties analyzed in the study

Group code	Enlarged group of specialties	Number of HEIs
08	Methods and Technology of Construction Industry	5
09	Computer Science and Computer Facilities	14
10	Information Security	5
11	Electronics, Radiocommunication systems	6
12	Photonics, Instrumentation, Optical and Biotechnical Systems and Technologies	6
13	Electro and Heat-Power Engineering	9
15	Mechanical Engineering	6
18	Chemical Engineering	5
20	Technosphere Safety and Environmental Engineering	10
23	Engineering and Technology of Land Transport	8
27	Control in Technical Systems	10
38	Economics and Management	20
40	Law	9
42	Mass-Media and Library and Information Activities	11
45	Linguistics and Literary Studies	7

Employment indicators according to the enlarged groups of specialties

The Map of graduates' employment according to the enlarged groups of specialties is divided by the reference lines into 4 sections:

Section 1 – "Successful employment" – high percent of employed graduates with salary higher than the average for Saint-Petersburg HEIs' graduates: 7 enlarged groups out of the 15 groups analyzed.

Section 2 – "Priority on salary when being employed" – lower percent of employed graduates with salary higher than the average for Saint-Petersburg HEIs' graduates: no enlarged groups in this section.

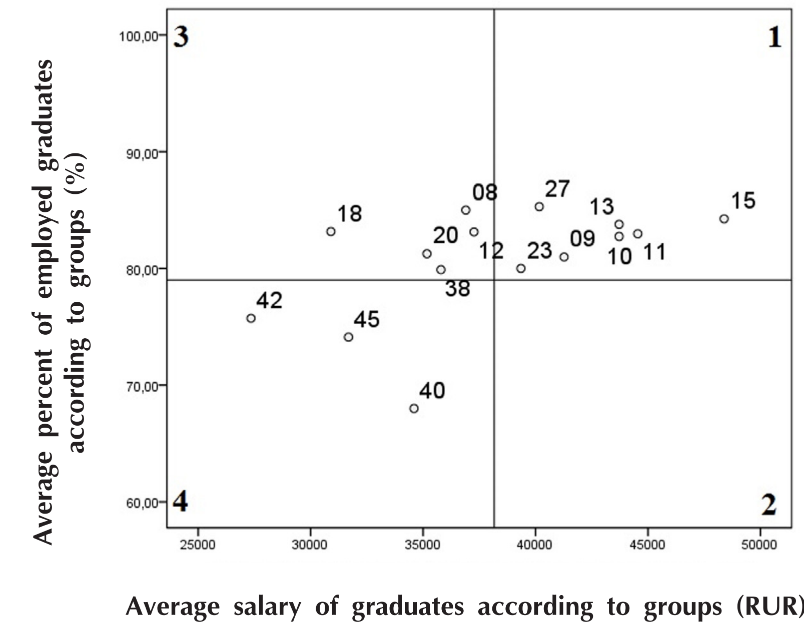
Section 3 – "Priority on employment" – high percent of employed graduates with salary lower than the average for Saint-Petersburg HEIs' graduates: 5 enlarged groups out of the 15 groups analyzed.

Section 4 – "Decreased employment indicators" – decreased percent of employed graduates, as well as decreased salary comparing to the average numbers of Saint-Petersburg HEIs' graduates: 3 enlarged groups out of the 15 groups analyzed.

It should be noted that enlarged groups of specialties with decreased employment indicators refer to the humanitarian specialties (Law, Linguistics and Literary Studies, Mass-Media and Library and Information Activities). As a result, engineering specialties excel humanitarian ones both in the share of employed graduates, and in their salary indicators.

It should also be brought to notice that among the analyzed enlarged groups of specialties the most prioritized group from the point of salary levels is "Mechanical Engineering". The salary in this group is 27% higher than the average numbers for

Fig. 1. Map of graduates' employment according to the enlarged groups of specialties



Saint-Petersburg and is equal to 48 384 RUR. At the same time, the least paid group is "Mass-Media and Library and Information Activities" – graduates' salary is 28% lower than the average in Saint-Petersburg and is equal to 27 348 RUR.

When speaking of the percent of employed young specialists, the most prospective groups of specialties are: "Methods and Technology of Construction Industry" and "Control in Technical Systems" – the percent of employed graduates in these groups is 6% higher than the average for Saint-Petersburg and is equal to 85%. The least demanded specialists are the ones from the "Law" group – its graduates get employed 11% less than the average indicator for Saint-Petersburg HEIs.

Allocation of HEIs according to their graduates' employment success

Allocation of HEIs according to their graduates' employment within the enlarged groups of specialties is of a particular interest. Specifically, for each enlarged group of specialties a leading HEI has been chosen with a significantly high number of either salary level, or percent of employed graduates comparing to the average numbers of the enlarged group. The criterion for choosing a leader is the indicators' (salary, percent of employment) increase for more than 10% comparing to the average numbers within an enlarged group of specialties.

Leading HEIs have been selected according to each of the two indicators – percent of graduates' employment and average salary. It should be emphasized that according to the indicator "Average salary" the leading HEIs have been selected for all of the analyzed groups of specialties, whereas according to the indicator "Percent of employment" leading universities have been chosen only for 4 enlarged groups.

Table 2 presents leading HEIs according to the indicator "Average salary" and states the discrepancy of salary comparing to the average numbers for a group.

It should be noted that at the moment of the research (August – September of 2017) the Portal for monitoring graduates' employment had no data on the employment rates of 2015 graduates of St. Petersburg State University of

Telecommunications and Saint Petersburg State University of Economics (UNECON). The indicated HEIs may also be leading in various enlarged groups, particularly, the economic university (UNECON) may lead in the "Economics and Management" enlarged group.

In order to illustrate the discrepancy in employment of graduates from different HEIs within a certain enlarged group of specialties, the data on salary allocation within a certain group is presented on the example of two groups – with the lowest and the highest discrepancy between leading HEIs and the average.

The group with the highest discrepancy of the average salary is the "Law" group. Fig. 2 shows that SPbU is one of the absolute leaders on salary level within this group and exceeds the average numbers for the group for 101%.

The group with the lowest discrepancy between HEIs according to the indicator "Average Salary" is the "Photonics, Instrumentation, Optical and Biotechnical Systems and Technologies" group (Fig. 3).

This group has an exceeding salary indicator for graduates of BSTU "VOENMEH"; however the discrepancy from the average salary of the enlarged group is less than 20%.

Thus, the leading HEIs on the "Average salary" indicator have been analyzed. At the same time, for some groups there also are leading HEIs for the indicator "Percent of employed graduates" (Table 3). It should be taken into account that there are a lot less groups with leading HEIs here and the discrepancy between the leading HEIs and

Table 2. Leading HEIs according to the average salary

Enlarged group of specialties	No. of HEIs in group	Leading HEIs	Discrepancy of salary from the average
Photonics, Instrumentation, Optical and Biotechnical Systems and Technologies	6	Baltic State Technical University "VOENMEH", BSTU "VOENMEH"	18%
Mechanical Engineering	6	Saint Petersburg State Forest Technical University, SPbSFTU	60%
Mass-Media and Library and Information Activities	11	State University of Aerospace Instrumentation, SUAI	72%
		Saint Petersburg State University, SPbU	11%
Chemical Engineering	5	Saint Petersburg Mining University, Mining University	27%
Technosphere Safety and Environmental Engineering	10	BSTU "VOENMEH"	28%
		Admiral Makarov State University of Maritime and Inland Shipping, Admiral Makarov SUMIS	22%
Methods and Technology of Construction Industry	5	Emperor Alexander I St. Petersburg State Transport University, PSTU	20%
Economics and Management	20	SPbU	78%
		Saint-Petersburg University of Management Technologies and Economics, UMTE	43%
		Saint Petersburg Electrotechnical University "LETI", ETU "LETI"	28%
		State Marine Technical University of St. Petersburg, SMTU	19%
Computer Science and Computer Facilities	14	ITMO University	38%
		Peter the Great St. Petersburg Polytechnic University, SPbPolyTechU	27%
		ETU "LETI"	21%
Electro and Heat-Power Engineering	9	PSTU	87%
		Mining University	15%
Law	9	SPbU	101%
		Saint-Petersburg State University of Architecture and Civil Engineering, SPSUACE	29%
Engineering and Technology of Land Transport	8	PSTU	36%
		SPbSFTU	13%
Linguistics and Literary Studies	7	BSTU "VOENMEH"	21%
		SPbU	15%
Control in Technical Systems	10	ITMO University	30%
		Mining University	13%
		ETU "LETI"	12%
Electronics, Radiocommunication systems	6	Mining University	20%
		ITMO University	11%
Information Security	5	SPbPolyTechU	33%
		ITMO University	14%

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the averages of the groups does not exceed 20% (compared to the discrepancy on the "Average salary" indicator).

Conclusion

As a result, the analysis of Saint-Petersburg HEIs graduates' employment according to the enlarged groups of specialties allowed determining groups of specialties with the most successful indicators of graduates' employment: "Computer Science and Computer Facilities", "Information Security", "Electronics, Radiocommunication systems",

Fig. 2. Enlarged group of specialties with the highest gap between leading HEIs and average numbers

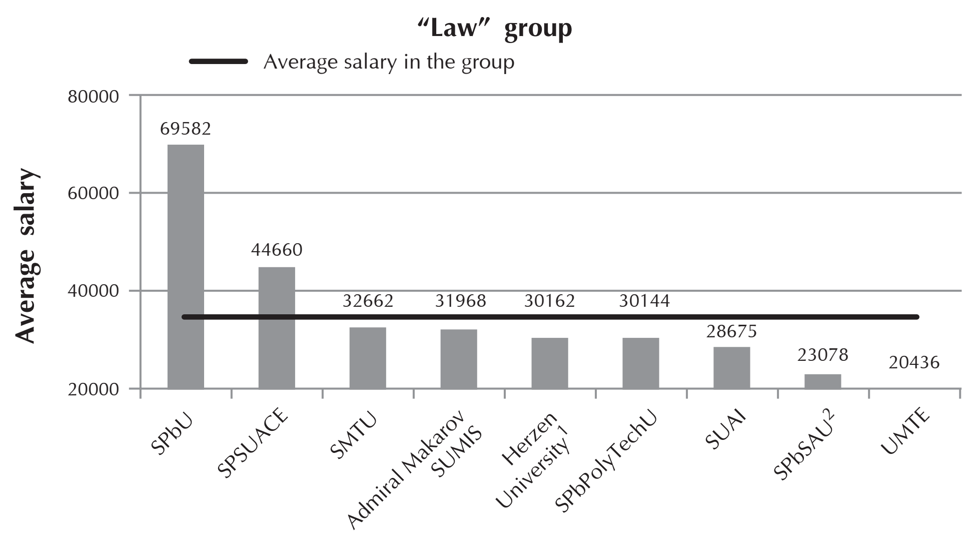
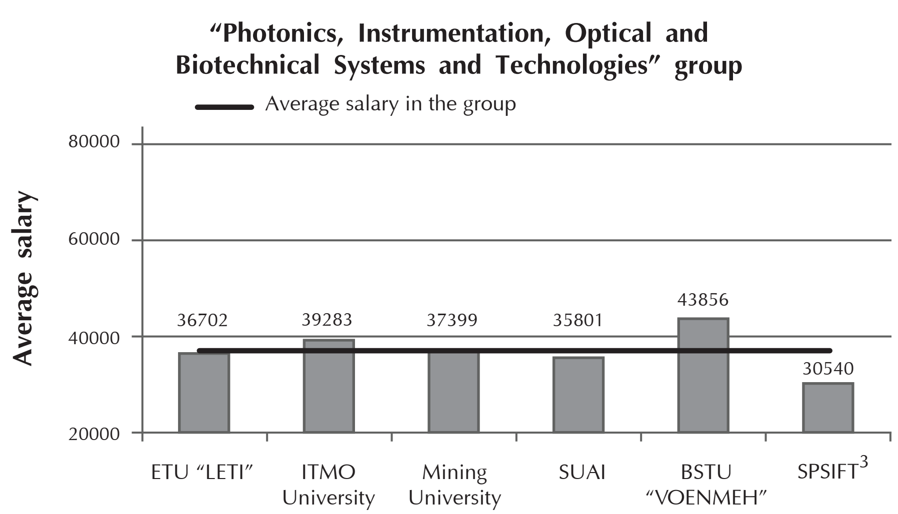


Fig. 3. Enlarged group of specialties with the lowest gap between leading HEIs and average numbers



[1]Herzen State Pedagogical University of Russia
[2]Saint-Petersburg State Agrarian University
[3]Saint Petersburg State University of Film and Television

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Table 3. Leading HEIs according to the employment percent

Enlarged group of specialties	No. of HEIs in group	Leading HEIs	Discrepancy of employment from the average
Computer Science and Computer Facilities	14	BSTU "VOENMEH"	12%
Law	9	SPbU	19%
Engineering and Technology of Land Transport	8	PSTU	12%
Technosphere Safety and Environmental Engineering	10	Mining University	10%
		Admiral Makarov SUMIS	10%

"Electro and Heat-Power Engineering", "Mechanical Engineering", "Engineering and Technology of Land Transport", "Control in Technical Systems". It is worth emphasising that success of graduates' employment according to the enlarged groups of specialties has been determined only for the most widespread groups of specialties, the ones that have graduates (over 25 people) in at least 5 HEIs in Saint-Petersburg.

Besides, data analysis permitted determination of leading HEIs for each group of specialties. For some groups there is a small number of leading HEIs, and, normally, indicators for these HEIs are slightly different from the groups' average (this is true for such groups as "Photonics, Instrumentation, Optical and Biotechnical Systems and Technologies", "Methods and Technology of Construction Industry", etc.). However a number of enlarged groups has outstanding leading HEIs, whose indicators are sufficiently higher than averages in these groups ("Law", "Electro and Heat-Power Engineering", "Economics and Management").

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Didactic Conditions of Industrialization Risk Mitigation in Engineering Education

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Abstract

The article deals with the issue of engineering education industrialization. The risks of engineering education industrialization are identified. The didactic conditions of their mitigation are grounded: arrangement and management of a student's autonomous work with possessed information (textbook) and raw information (research engineering data).

Key words: didactic conditions, engineering education industrialization, autonomous work, textbook.

The history of engineering education in Russia is closely connected with the history of economic transformations in the country. In a time of transition to innovative economy, the Russian economy suffers from the lack of engineering personnel. That reasons are:

First, training of engineering staff does not correspond to economic growth. Only 27,6% of university students are trained in engineering specialities.

Second, students have the right to acquire professional knowledge and skills relevant by the time of graduation from a university. Today, by graduation from university a graduate has 90% of outdated knowledge as the knowledge update rate is 15% per a year [1].

The demand for engineering personnel defines a general goal for engineering education – development of breakthrough technologies, training of demanded personnel for industries [2].

Educational reforms always addressed the challenges of economic development and encouraged new challenges. At present, the key contradiction is a discrepancy between graduates' professional competencies and growing demands of high-tech enterprises, design and scientific institutions. To provide competitive advantage for the Russian economy means to make a technological leap forward. To make the technological leap means to industrialize engineering education. Russian engineering education has some experience in industrialization of training: in the period of planned economy from the 1930's to the transition of Russia to market economy in the 1990's the engineering education was tightly connected with industry and science. Taking into account the advantages and disadvantages of previous experience from the 00's of the 21-st century, under the condition of transition to innovative economy industrialization of engineering education was performed through education corporation of "science – education – production plus innovation" system. Hence, the task of university teacher is to provide dialectic development of education corporation as a system, the driving force of which is a science.

We have revealed possible risks of education development:

Risk 1. Instead of demanded engineering personnel the real economy of Russia could have a functionally illiterate graduate of engineering university without fundamental (natural science) constituent of engineering training. For the students learning at engineering universities physics is a basis for mastering technical courses. According to the Educational Standards of the Federal State Educational Standard for Higher Education (HE FSES) curriculum guidelines are developed. On average from 9 to 12 credits of total credit number are provided in the curriculum guidelines for physics course depending on Bachelor specialization. In this way, the curriculum guidelines correspond to the minimum workload. The minimum workload implies students' ability to reproduce typical situations, use them for solving the simplest problems [3]. In contrast, the previous curriculum was close to a basic level in terms of workload. It assigned 500-550 hours (15 credits) on average. Comparative analysis of existing curricula has led us to the conclusion: new curriculum guidelines on physics initially include the trend for reduction of Bachelors' knowledge quality in future.

Risk 2. Instead of demanded engineering personnel the real economy of the country could have a functionally illiterate graduate of engineering university without teaching first-year students to learn independently. Students' autonomous work is one of the conditions for students' training that would give a teacher the possibility to compensate that small number of classroom hours assigned for learning physics at an engineering university. Until the mid-90's of the 20-th century the previous curriculum provided 53% of total learning time for students' classroom activity with a teacher. Independent work was divided into classroom independent work under a teacher's supervision (13%) and autonomous work (34%). Classroom work was the main form of learning activity and took approximately two thirds of student learning time. Starting from the 00's of the 21-st century, students' independent workload assigned by the HE FSES of the second generation increased in percentage of workload for learning a course. Today, this share is 50 %, of which more than 90 % are autonomous work done without a teacher. The instructive letter "On intensification of students' autonomous work in higher institutions" recommends increasing its share up to 60-70 % more [4]. Hence, if independent work at school "is largely limited to home assignment consisting of exercises similar to those done in class" (V.L. Kraynik) [5, p. 54], a significant part of learning material on physics at university can be studied by first-year students autonomously.

From O. Vasilyeva's speech, the Ministry for Education and Science of Russia in mass media: no university should lower the threshold of Unified State Exam (USE) score less than 60 points. It means that universities are to enroll only those who are able to learn there. However, only small percentage of pupils can pass physics exam. In the condition of demographic pitfall, low USE score on physics gives students the right to be a student of engineering university. To identify first-year students' readiness for learning physics autonomously with "declining" assistance of a teacher, let us consider the outcomes of diagnostic test on physics centrally performed at Tyumen Industrial University [6].

The histogram of distribution density of testing outcomes allows estimating the character of test outcome distribution and students' division into preparation levels. It also allows revealing that:

1. Less than 20% of the first-year students are able to learn information independently.
2. More than 80% cannot master physics independently even at minimal level of workload and need teacher's assistance.

The analysis of placement test outcomes has brought us to the conclusion:

1. It is necessary for physics teachers to take into account the knowledge level of each first-year student for learning university course of physics.
2. It is enough to organize and manage the autonomous simultaneous work of 80% students with processed information (textbook) and 20% students with raw information (research engineering data).

In the period of global informatization, the demand for acquiring increased amount of unprocessed information contradicts to time limitation intended for learning unprocessed information in the classroom. In this context the issue of organization and management of students' autonomous work with processed information (textbook) and raw information (research engineering data) is becoming rather urgent.

The concept "autonomous work" is a multi-component and complicated phenomenon. Under students' autonomous work we mean work arranged and done by the student him/herself both without direct and indirect supervision of a teacher under the condition of a student's readiness for independent learning. To achieve the goal of training student ready for autonomous work with processed and unprocessed information, we used systematic and scenario-based research methods. A system is considered as a means of problem solution, whereas scenario-based approach is focused on studying a definite situation and developing a system based on it that meets specific conditions and requirements [7].

There is no single way of organization (the key statement of scenario-based approach), but there are different types of organization system defined by needs, development level, and interaction with the environment. It means that structure of autonomous work of 20% (Group A) and 80% (Group B) of first-year students with physics textbook is to meet the demand and knowledge level of students from each group and a particular student as well as their interaction with the information environment.

One particular student has to consider autonomous physics learning with textbook as autonomous work to develop a skill of comparing the account of the same issues in different sources, expressing his/her own opinion. The main task of a student is to learn independent thinking within a year or a year and a half. "Nobody can teach us think independently, if you don't want to do this by yourself" (P.L. Kapitsa) [8, p. 9]. Every student interprets and perceives physics differently. "Different authors design textbooks on general physics presenting the subject in a way, which is familiar for them. You should select a textbook, which is mostly to your liking" (P.L. Kapitsa) [ibid, p. 7]. It should be a textbook, whose author thinks in the same way as does the student who learns physics with individual textbook. It means that one particular student can understand only that textbook, which was developed by him/her.

We have developed a model of student-centered successive textbook on physics. The student-centered successive textbook serves as an example of students' independent work with physics textbook at the lecture and self-training after lecture. Student-centered successive textbook means here a structured textbook consisting of separate textbooks: basic, successive, and student-centered. Textbooks, in their turn, consist of separate modules. These modules are combined into a thematic cluster [9].

Structural-functional design of student-oriented successive textbook on physics serves as a framework for organization of students' autonomous work with processed information (physics textbook) with a "declining" teacher's assistance [10].

Let us consider implementation of organization framework of the students' autonomous work based on the scheme of developed model without preparatory reading of training text with the set limits: duration – 210 min, venue – classroom, materials – in electronic and printed format, aids – physics textbook and mobile phone (Table 1).

We use the suggested framework (structural-functional model of student-oriented successive textbook on physics) of organizing students' autonomous work with physics textbook as a scheme, by means of which we can develop a new models of students' autonomous work with processed information (textbook) and raw information (research engineering data). The model is a relatively fixed structure, whose stability is maintained by limitation for the autonomous work of this type.

Table. 1. Structural elements of classes and student's activity with training text in the classroom

Structural elements of classes	**Student's activity with training text**	**Student's activity with training text "Electrostatics" [11, p. 160-167]**
At the classes		
At the lectures		
Stage I. Identification of students' knowledge and reading competence on the study theme: 1. Lecture task setting: a) knowledge updating;	A student works with a text given by a teacher independently, reads the necessary chapters to search for the main idea. He/she looks for the answer to the question: what is this text about? The main idea of a training text most often coincides with the title of chapter. He/she updated the background knowledge on the study text to find the answer for the question: what do I know about it? He/she prepares for new knowledge.	Dielectrics in the field. *I know:* 1. Dielectrics. Types of dielectrics. 2. Polarization of dielectrics. Forms of polarization. *I can* classify dielectrics. At this stage a student updates his/her knowledge, namely, his/her activity focuses on filling in the gaps in school training on the theme "Dielectrics in the field". The conditions for mastering the topic of the university course are created.
b) student's motivation;	A student looks through the main text in the chapter. A student needs to achieve the goal: to update and extend the knowledge and wants to acquire new knowledge.	
в) identification of knowledge to be taught.	A student identifies new knowledge that is to be learnt. New knowledge of the training text most often coincides with the title of paragraph in the textbook. He/she sets the tasks: I want to know... I want to be able to...	*The lecture theme* "Dielectrics in the electrostatic field". *Outline:* 1.Polarization as a physical phenomenon. 2. Physical magnitudes characterizing polarization: polarity, voltage of electrostatic field, displacement vector, dielectric susceptibility, dielectric permittivity. 3. Physical laws of polarization: Gauss theorem of electrostatic field in dielectric, the law of line refraction and electric flux lines, Coulomb's law.

Structural elements of classes	Student's activity with training text	Student's activity with training text "Electrostatics" [11, p. 160-167]
2. Theme and outline of a lecture.	Students together with a teacher state the theme of a lecture. The lecture theme coincides with the main idea of the training text in general. They compose the outline of lecture. The items of lecture outline most often coincides with the titles of paragraphs of the textbook.	*The lecture theme* "Dielectrics in the electrostatic field". *Outline:* 1.Polarization as a physical phenomenon. 2. Physical magnitudes characterizing polarization: polarity, voltage of electrostatic field, displacement vector, dielectric susceptibility, dielectric permittivity. 3. Physical laws of polarization: Gauss theorem of electrostatic field in dielectric, the law of line refraction and electric flux lines, Coulomb's law.
Stage II. Mastering new knowledge: 1. Learning and initial mastering new knowledge.	A student makes notes of a lecture. A lecturer divides the lecture content into semantic parts. After delivering each part lecturer arranges discussion according to the generalized outline of structural elements. When mastering new knowledge, a student reads the main text of the textbook paragraph to find the answer for the question: what is said about main idea in the paragraph? From the initial mastering of new knowledge – to extra-textual component of the textbook paragraph. A student makes exercises to initially master new knowledge. He/she adjusts mastering new knowledge, corrects the lecture notes.	
2. New knowledge reinforcement.	A student solves a training problem. When mastering new knowledge, a student turns to the extra-textual component of the textbook chapter. He/she does the tasks for secondary mastering of the known new knowledge. He/she adjusts new knowledge secondarily. He corrects the lecture notes.	

Structural elements of classes	Student's activity with training text	Student's activity with training text "Electrostatics" [11, p. 160-167]
3. New knowledge assessment.	A student thinks over the new knowledge. A student turns to the main text of the textbook chapter. He/she corrects the lecture notes.	
At the classes		
Complex application of new knowledge.	A student solves a training problem. I know and be able to do the tasks: 1) of complex application of new knowledge: a) in familiar situation, b) unknown situation, c) to transfer the knowledge into new condition; 2) of generalizing and systematizing new knowledge. He/she adjusts the new knowledge.	
At the lab work		
Complex application of new knowledge.	A student solves an experimental training problem. I know and be able to do lab work.	

In conclusion, student-oriented module of structured textbook is, firstly, a result of one particular student's autonomous work with processed and raw information; secondly, a student's development trajectory as an element of "science – education – production plus innovation" system.

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The 50th Anniversary of VAZ: Higher Education in Togliatti as an Indicator of Innovative Development for PJSC "AVTOVAZ"

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Abstract

The Volga Automobile Factory and Togliatti State University (TSU) were simultaneously founded. The development of both institutions was conditioned by mutual interaction in a number of aspects including scientific and research ones. The university contributed to the technical, technological and innovative solutions applied at the factory. It is also TSU that provided engineering staff for the factory. The modern condition of higher education in TSU reflects the same situation in PJSC "AVTOVAZ", that is system crises in science and production. Both institutions have the same objective and subjective problems: the lack of funding for research, the cut of engineering structures (departments) at the factory, the decrease in university science activity, staff shortage, and subjective decisions made by top managers.

Key words: history of development, higher education, automotive industry, PJSC "AVTOVAZ", staff training, innovative development, social and economic situation, "WSET" department, TSU, joint projects, engineering, university science, problems in funding.

Interconnection between science and production is the key factor in any industrial branch and the entire regional economy. The failure of such relationships leads to decline both in higher education system and production. The current state of interaction between Togliatti State University (TSU) and VAZ (Togliatti) causes worries about the regional economic development. Thus, the aim of the research is to analyze the interaction of the departments that are parallel to each other in TSU and VAZ both from a historical perspective and current status.

The development of VAZ is closely connected with the development of higher education system in Togliatti, in particular Togliatti Polytechnic Institute (now Togliatti State University). These two institutions had a parallel development and influenced each other in the spheres of education, science and innovation. The history of TSU, in its turn, is closely connected with the department "Welding and Soldering Equipment and Technology" (WSET) (now the department "Welding, Fabrication and Allied Processes"). Currently, it is one of the leading departments providing engineering training in TSU and the only department in Samara region that provides training in welding and soldering fabrication. B.E. Paton, G.A. Nikolaev, and N.N. Rykalin, the members of the Academy of Science of USSR, made a significant contribution to the WSET development. They supported scientific schools and research in developing technology for three-phase arc deposition and welding (the director was V.I. Stolbov).

Prof. S.V. Lashko, and Prof. K.A. Vitke (GDR) promoted research activities in soldering theory and technology (scientific school of Prof. B.N. Perevezentsev). In the 70-s and 90-s of the 20th century the department laboratories and facilities were updated with the help of the local enterprises that donated modern welding equipment to the department. For example, OJSC "Volgocemmash" (via the leading welder M.G. Kozulin) donated unique ESW welding equipment and Auto SAWs. PJSC "AVTOVAZ" (via the deputy chief engineer E.I. Brekkel') contributed to the ERW laboratory equipped with robot machines for resistance spot and seam welding.

Active collaboration between the department staff and VAZ, the leading automobile manufacturer in the USSR, and enterprises of the defensive industry ensured intensive development of the scientific schools. The heads of the enterprises made cooperation agreements with the department to deal with the challenges relating to new technologies and equipment development of the enterprises. These agreements involved the scientific staff members of the department. For example, from 1970 to 2008, 30 inventions and 10 international patents (including the USA, Great Britain, Japan and France) were made in the frame of 7 agreements [1]. The innovations made by ERW laboratory of the department were introduced in AvtoVAZ and in the auto plant in Ul'yanovsk. The most efficient inventions for the VAZ factory are long wearing flexible water-cooled cables for overhead spot welders, noncontact pocket device to measure current rate (the inventors are M.D. Banov (assistant professor of TSU) and A.I. Oshkin and V.A. Klenin (engineers of AVTOVAZ)).

By the end of the 20th century, production intensification, increase in load on equipment, aggressive process liquids and environments put new challenges before the socially-owned enterprises. The auto plant faced unit performance degradation and their premature failure. These problems rose to the level to be solved by the Government of the Russian Federation. Thus, in 1980, the All-Union program "Remont" (repair) was adopted in the frame of GOSAGRPORM. In the 90-s, the Russian Ministry of Education launched a programme in renovation and surface engineering. It resulted in development of new research area at the department "Equipment and Technology for Increase in Wear Resistance and Recovery of Machinery Parts". A new department "Recovery of Machinery Parts" (RMP) was founded in TSU. V.V. Eltsov, assistant professor, who headed the new department, had graduated from WSET. The department was immediately involved in research, educational and cooperative activities with the leading enterprise of the city. For example, the department made an agreement with AVTOVAZ to develop repair technology for some expensive parts of H-type eccentric press "INNOCENTI – 400". The developed technology allowed doubling the service life of the parts.

AVTOVAZ and TSU collaborated in engineering training. There was a demand for targeted training of the graduates at the plant. Besides, highly qualified specialists of AVTOVAZ participated in educational activities of the University and were involved in research projects conducted by post-graduate and doctoral students. Particularly, it was leading specialists of AVTOVAZ who were the chairmen of the State Attestation Commissions (SAC) at the departments of TSU. We should mention the names of A.K. Tikhonov, the head of Laboratory Study Administration ("WSET" department), B.N. Nikolenko, the head of Master mechanic administration ("RMP" department), and S.N. Perevezentsev, the Chief Technical Officer of dies and mold tools.

In its turn, TSU offered advanced training courses for the AVTOVAZ staff. For example, G.M. Kokotov, the chief technical officer of Assembly shop, and E.I. Brekel', the deputy chief engineer of the same shop, defended thesis on the base of TSU laboratories "Welding Sources" and "Welding Automation" (the heads of the laboratories are assistant professors G.M. Korotkova and R.A. Tzepenev). A.K. Tikhonov, the head of Laboratory Study Administration, A.G. Azizbekyan, the deputy manager of the Laboratory Study Administration, and M.M. Krishtal, the head of the Material Testing Laboratory, conducted their research on the base of "Material Technology" laboratory supervised by Professor A.A. Vikarchuk [2]. Their research accounted for papers published in scientific journals, patents, inventor's certificates, their coauthors being the University staff members and the factory employees [3-8]. The research done by V.Ya. Kokotov and E.I. Brekel' resulted in manufacturing control and measuring instruments CMI-5 to control the parameters of electric resistance welders both in setup and operating modes. In its turn, using the research results of mutually conducted projects the TSU teaching staff published some manuals and text-books approved by the Ministry of Education for higher schools and vocational colleges [9-12].

In1992 the rector of TSU V.I. Stolbov, and the chief executive officer of AVTOVAZ V.V. Kadannikov initiated a training course "Foundry Equipment and Technology" provided by the department "WSET". It met the demand of the city manufacturing enterprises, first of all, PJSC "AVTOVAZ". More than 100 graduates finished the course supervised by Prof. P.I. Vershinin, and assistant professor A.I. Kovtunov.

The interaction between PJSC "AVTOVAZ" and TSU was planned in recent history (2000 – 2016) as well. Several innovative technical and human science projects were partly implemented. In 2005, two TSU departments, "Vehicle Technical Maintenance and Repair" and "Vehicle Part Reclamation" merged into a department "Vehicle Technical Maintenance and Part Reclamation". The department staff did active research and teaching work in this field [13]. In 2011, the department merged with the department "Vehicles and Tractors" to form a new department "Vehicle Design and Maintenance", which is still a TSU structural unit. The department was headed by N.S. Solomatin, who later became a project head manager in the Engineering Office of PJSC "AVTOVAZ".

In March 2012, an extended session of the Scientific and Technical Board (STB) took place in TSU. It was chaired by Alain Diboine, the engineering director of "AVTOVAZ". The leading specialists of "AVTOVAZ", rectors and vice-rectors of TSU and Samara University took part in the session. One of the issues under discussion was the interaction of "AVTOVAZ" with the universities and research institutes in the frame of the Innovative Development Program. It should be mentioned that TSU is one of the supportive universities involved in the Innovative Development Program of "AVTOVAZ". The topic was introduced by Amanov S.R., the vice production manager of "AVTOVAZ". The report resulted in a decision to start procedures aimed at developing priority research areas in the medium term (to 5 years) and in the long term (to 10 years). The leaders of Scientific and Technical Cooperation departments were recommended to take into account the "AVTOVAZ" strategy of the car product range development, and the provisions of the Innovative Development Program [14]. According to the Program, since 2012, TSU and "AVTOVAZ" are to conclude agreements on cooperative research work in the following fields:

- Application of modern and innovative materials and technologies in LADA vehicles.
- Techniques for tool-wear rate prediction by means of acoustic emission signals while cutting.
- Techniques to identify open porosity and surface graphitizing on inner surface of the vehicle parts by means of nondestructive testing.
- Techniques and devices for infrared nondestructive testing of electric resistance spot-welded joints.
- Increase in wear resistance of aluminum pressure die casting tooling.
- Application of acoustic emission to register crack formation during fatigue tests.

D.G. Ruzaev, the director of the research center, AVTOVAZ Engineering administration Office, provided the higher education institutions, the members of the united STB, with the information about the main focus areas in the field of new material design and processing developed by AVTOVAZ. One of the focus areas was the development of future-oriented technological processes, invention and testing of new metal and non-metal materials. For example, in the frame of the activities related to "Future-oriented technological processes" it was planned to study the following issues: [15]

1. Advanced welding technologies and processing of car parts by means of high-concentrated power sources (arc, plasma, and laser technologies).
2. Application of high-performance energy-saving technologies for joining car parts (welding, nonelastic deformation, assembly).
3. Testing of machinability of the materials and performance specifications of the tools to enhance efficiency of cutting and grinding of the parts.

However, it should be noted that most of the mutually planned research projects were not implemented, with the top staff of the alliance "Renault-Nissan-AVTOVAZ" changes and Bo Andersson being appointed as the top-manager in 2013. It is obvious that the priority tasks of the alliance do not include the development of innovative engineering in Russia, since it may create competition for the western auto manufacturers. "AVTOVAZ-Renault-Nissan" alliance may have other reasons, but thinking of nothing but the profit, the alliance should remember that the auto industry is funded much by the Russian Federation. Thus, it is economically unsound for the region and the whole Russia to have only Complete Knock Down manufacture without engineering departments, research and advanced development and staff training, which implies cooperative activities with the higher education institutions [16].

The interaction between TSU and AVTOVAZ in the areas of staff training and R&D is not active enough. The plan of target training meant to provide 100 graduates for AVTOVAZ each year from 2010 till 2015. In fact, 100 graduates finished the course only in 2011and 30 students in 2012 with the contract being early cancelled afterward. The EU economic sanctions against Russia must facilitate the process. To be true, the target training contract was renewed in 2017 and hopefully will be fully fulfilled.

TSU, being the basic higher education institution that provides the city with the staff, continues research, innovative and education activities in cooperation with other auto manufacturers, chemistry industry as well as with social and educational institutions. It is proved by the status of Regional Supportive University. TSU is currently carrying out four public grants with the total fund of some million rubles. The federal public grant No. 220 (90 million rubles) was awarded to a cooperative project of TSU (prof. A.A. Vikarchuk) and E.C. Aifantis, the key scientist in "Material Technology" [17]. In addition, the Ministry of Economic Development decided to establish the area of advanced development (AAD) "Togliatti" [18,19]. The city administration developed a program of activities implemented in the frame of the AAD. According to the program TSU plays an important role as the Regional Supportive University [20]. It will allow increasing the regional investment attractiveness and tax revenues, as well as launching new enterprises, which will reduce social tension. Thus, no matter what development scenario PJSC AVTOVAZ may choose, the higher education in Togliatti will serve as an indicator of innovative development of the city and the Povolzhye region.

Conclusion

1. TSU innovative and research developments were actively implemented in various production lines of VAZ autoplant in the 70-90-s of the 20th century. It ensured engineering development both in technological equipment and automotive manufacturing.

2. The Current interaction between PJSC AVTOVAZ and TSU in the area of staff training does not contribute to addressing the challenges in social and economic spheres of the region. However, the foundation of AAD "Togliatti" should spur a new spiral in the interaction between PJSC AVTOVAZ and TSU in the area of staff training and research and development, but now in the frame of Supportive University.

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UDC 378.22

Training Students to Monitor Product Quality in CAD for Car Industry

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Abstract
Training of skilled specialists capable of designing qualitative products within the car industry could be hardly secured without the introduction of modern automated design systems into education programmes. Within the degree programme in "Mechanical Engineering", 15.03.01 offered by Togliatti State University Siemens PLM Software NX is applied. The proposed programme is comprehensive and aimed at product quality enhancement at the stage of product design. A great attention is also paid to evaluating the quality of the products subject to pressure shaping via CAE program Autoform, Deform and LS-DYNA.

Key words: bachelor's degree programme, curriculum, car industry, automated design, model design, product quality, metal pressure shaping, comprehensive education, product lifecycle management, CAD.

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A modern car should be functional and meet high quality requirements. These characteristics should be considered at the stage of car design and manufacture. The experience of modern car manufactures indicates that the product quality is defined not only by its configuration, but also by the system of arrangements that constitute a part of nominative documents, standards and various programs of international communities and enterprises related to the car industry.

PLM (Product Lifecycle Management) is currently a fundamental software tool to support the development of highly-competitive products. It helps manage data at the stage of car design and manufacture. Precisely, it includes CAD, ERP, and SCADA. To operate these systems, there is a need for the specialists who possess knowledge of the up-to-date engineering technologies and have gained working experience in IT and PLM software. They are able to provide professional support to car manufacturers.

Togliatti State University offers the bachelor's degree programme in "Mechanical Engineering", 15.03.01 and master's degree programme in "CAD in Mechanical Engineering", 15.04.01 aimed at training specialists capable of fulfilling a wide range of activities related to modern car design, use of up-to-date technologies and the integrated PLM software.

Special knowledge of mechanical engineering fundamentals and CAD basis obtained by bachelor students is consolidated within the master's degree programme. Alongside enhancement of professional skills in certain fields of mechanical engineering, future master students also get familiarized with the disciplines related to PLM software and gain relative working experience.

The curricula of cross-engineering and special engineering courses are designed so that bachelor students are explained how to use CAD system in the mechanical industry. For this purpose, computer-aided design and management tools have been introduced into the courses of professional training both for students and faculty members.

Quality product courses are of particular importance in the discussed education programmes. The issues related to product quality management (CAD system and SCADA) are considered.

Quality criteria for geometric layouts intended for electrical models of products are listed in Russian All-Union State Standards (GOST) [1, 2]. They are based on the international standard ISO/PAS 26183:2006 [3]. In NX software, the model quality requirements are developed via VDA and SASIG (ISO/PAS 26183) [4, 5].

When designing and developing new models in CAD systems, students are trained to use various tools of inspecting the geometry of car detail models and searching for errors in certain product models. For example, technology of visual presentation HD3D supplemented by NX Check-Mate tools is applied in Siemens PLM Software NX. It ensures direct visual interaction, thus, facilitating error search and defect elimination (fig. 1, fig. 2).

The inspection reports are also developed in NX software. They include the certain values, dimensions, structure and local geometry defects based on the enormous number of features. A user can independently initiates inspection and select the programs suitable for error detection, description and visualization. Fig. 2 illustrates the defect search menu based on the minimum bend radius criterion.

Master and bachelor students learn the fundamentals of model quality inspection in the following courses: “CAD fundamentals”, “Modeling of objects and processes of mechanical engineering in CAD”, “CAD of processes and accessory for sheet-metal stamping”, “CAD fundamentals in PLM”, “Engineering analysis of objects and processes in CAE” and demonstrate the gained knowledge in course papers and final qualification works.

The proposed programmes are comprehensive and aimed at enhancing product quality both at the stage of design and development of technological processes and accessory. A great attention is paid to the quality evaluation of the products subject to pressure shaping via CAE program Autoform, Deform and LS-DYNA. During practice and lab classes, students master the methods to detect such defects as rupture, thinning, springing, scratch, underfilling and other ones that peculiar either for sheet-metal stamping or bulk forming. Numerical

Fig. 1. Results of detail geometry inspection in HD3D NX.

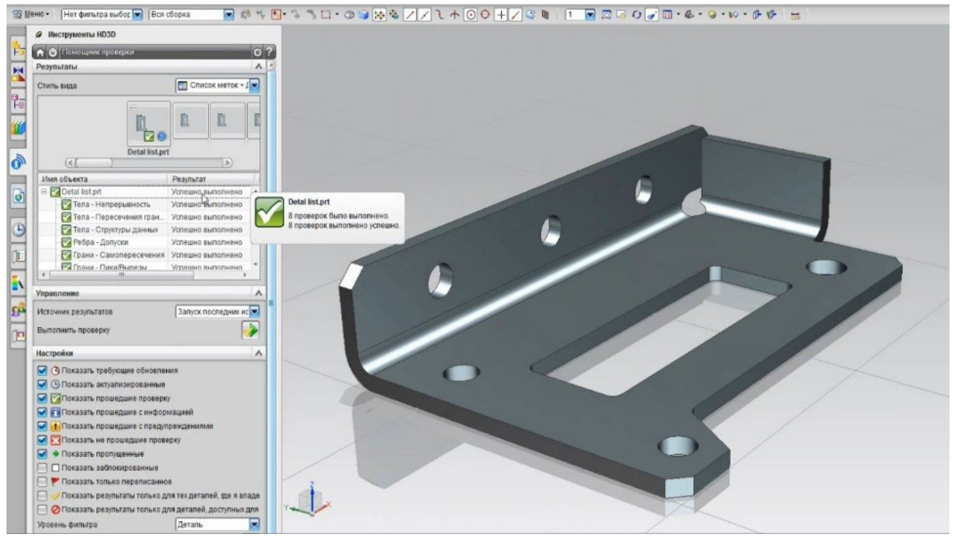
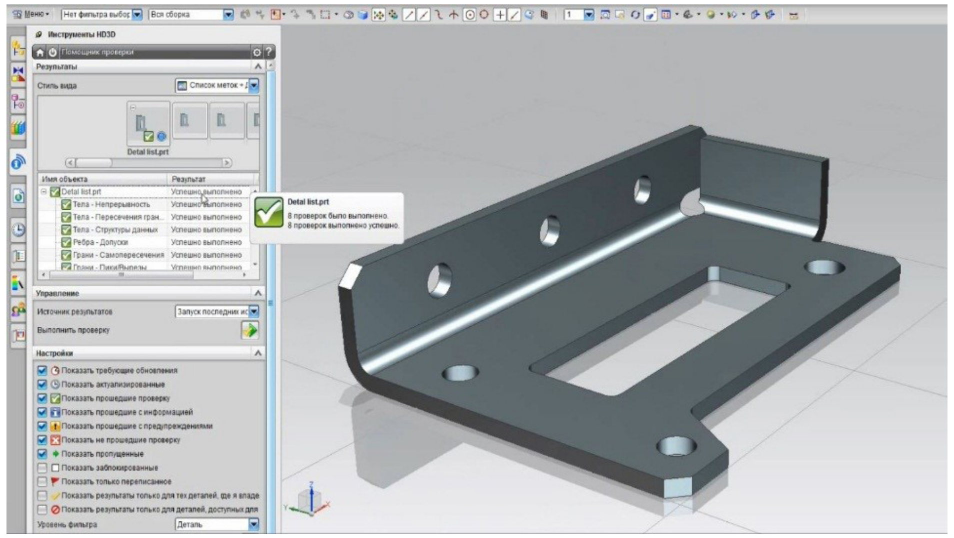


Fig. 2. Visual report menu of detail workability inspection in NX software



experiments help students understand the principles of detecting and eliminating the possible reasons for manufacturing defects and enhance the product quality in the car industry.

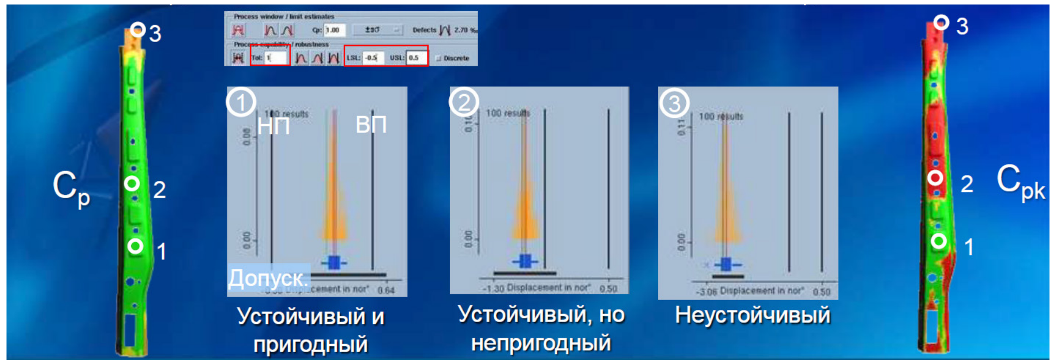
Statistical analysis is also of great importance in the study of sheet-metal stamping processes and their workability. A number of master’s dissertations are devoted to modeling various technological processes, precisely sheet-metal stamping in accordance with GOST R 50779.44-2001 [5]. Determination of reproducibility indexes and usability of technological processes allow making the conclusion on stability and availability of technological process management [6]. The forecast of product quality including the above-mentioned parameters is carried out via a great number of tools which detect the product defects at different manufacturing stages (fig. 3).

Further enhancement of training students capable of using the methods of quality improvement via CAD in the car industry is associated with the introduction of CAM quality control.

Conclusion

To shape the required graduates’ competence in automated object and process design that ensure manufacture of highly-qualitative products could be achieved only by means of comprehensive education programmes which embrace CAD fundamentals both at the stage of model design and development of technological processes and accessory.

Fig. 3. Stamping reproducibility indexes in Autoform



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UDC 378

Modernization of Personnel Training for Economic Development

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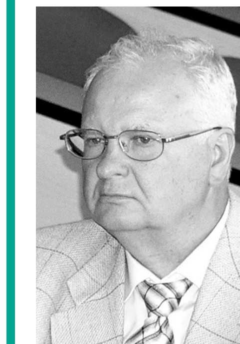
Abstract

This article considers the need to modernize the national system of training personnel with a university degree to ensure the growth of industrial output and the significant increase in the production of innovative products. The task of universities is to improve pedagogical skills of teachers so that they could efficiently use modern teaching technologies. Universities must generate students' fundamental competence, which is the commitment to quality. It is proposed to discuss new principal approaches to the system of education and upbringing. The article expresses the view that relatively soon the training of graduates with a Bachelor's degree in technical fields may hamper the development of modern innovative economy.

Key words: quality, economy, education, bachelors, engineers, competence, time challenges.



V.P. Soloviev

T.A. Pereskokova

It is generally accepted that the modern world is the world of quality, and we constantly witness it. In life, we want and sometimes demand to receive products or services of the highest quality. And what about the "return"? How do we behave when we produce our own products or provide services to anyone? And how do we get along with our neighbours? What do we teach our children? How do we drive a car? How do we repair roads? How do we teach and provide medical care for people?

For all advanced countries, the quality of products, which is currently determined not only by physical, but also intellectual capital, has become the driving force of development.

It may be said that knowledge economy is becoming one of the main challenges of the XXI century.

This takes place at a time when the world economy is already experiencing the trends of the third industrial revolution. It will result in the decrease in workers engaged in material production and the majority of them will be involved in intellectual work, such as development, research and design.

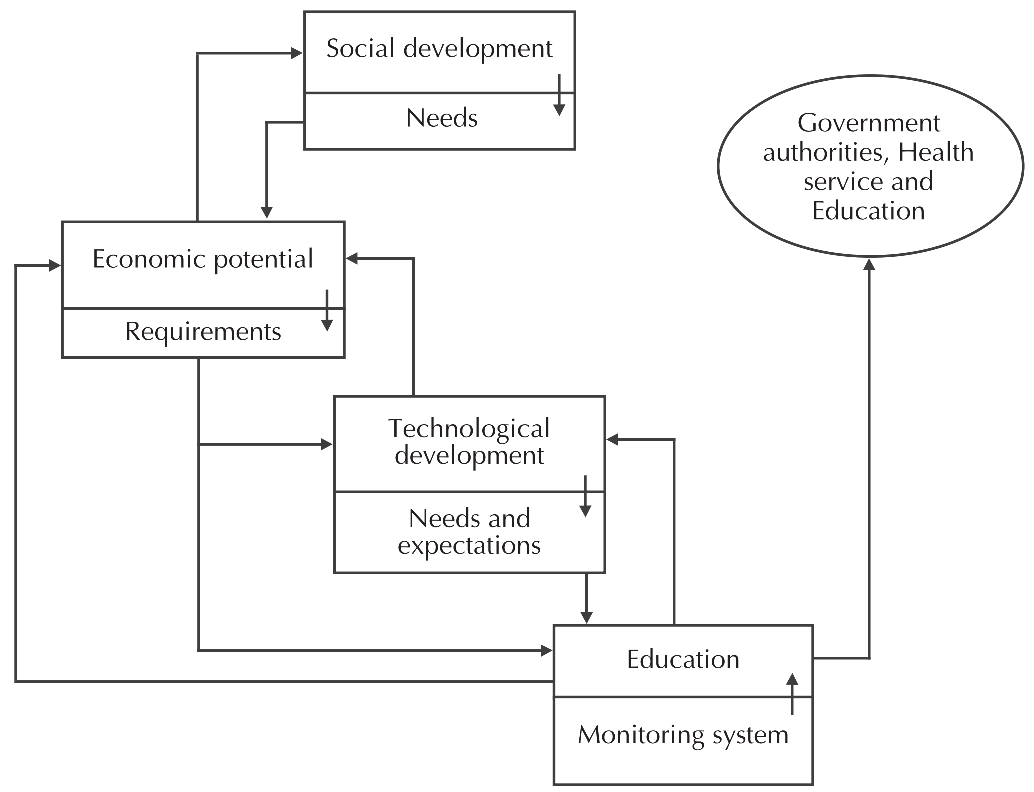
It means that economy needs employees of the new formation, able to meet time challenges. This is the task of education system. In the twenty-first century, it must not simply provide knowledge to students, but also guarantee their creative development.

The mutual relationship between education and economy is presented in Fig. 1.

This diagram clearly demonstrates that education is the foundation of social development. In his work "Russia: Virtual and Real Political Prospects", M. Urnov, the National Research University Higher School of Economics, notes that the shortage of qualified personnel is the key factor that hinders the economic growth and modernization of Russia.

In 2003, the Russian Federation became a full member of the European educational

Fig. 1. Relationship between Economy and Education



process (Bologna, Italy). Obviously, the general public was optimistic about significant changes in the educational process through the principle of students' centricity and competence-based approach to planning and implementation of educational programmes. However, in reality, the educational process hardly changed. What we saw was only a mass transition to the three-level training of bachelors, masters and postgraduates. Some educational fields continued training of specialists.

In the newspaper article "Do We Have a Plan?" ("Arguments and Facts" No23. 2016), Academician A. Aganbegyan of the Russian Academy of Sciences, underlines, that "In order to resume social and economic growth, it is required to move to a single goal-oriented economic policy. It implies the transition from reduction in investments to their accelerated growth. It concerns not only investments in fixed assets, such as machinery, equipment, etc., but also investments in the **"knowledge economy"**, which covers research, education, information technology, being the main component of human capital".

We consider it necessary to emphasize the importance that E. Deming, the founder of Quality Management, attached to education (training). In his writings he repeatedly stressed, "**There is no substitute for knowledge. We should look at education as an investment, not as costs**".

In general, quality does not only embrace the quality of products and services, but also the quality of product engineering processes, and therefore, the quality of employees, who manufacture these products. They should all be involved in the ideology of quality.

The adoption of new version of ISO 9000 base standards in 2015 by the International Organization for Standardization (ISO) was the organization's response to time challenges associated with the increasing economic crises, the intensification of competition and the growing role of intellectual capital in achieving goals of quality of products and services. Russia approved these standards nationwide.

In this regard, let us consider new approaches to the system of higher education and management of educational organizations to ensure the high level of students' training at Russian universities. Especially it concerns those students, who are planning to become engineers.

Professor K. Ishikawa, the famous Japanese Quality specialist, wrote in his book "Japanese Management Methods of Product Quality", "I keep saying that Quality Management begins with training of personnel and ends with training personnel".

Let us take the advantage of the well-known Japanese proverb that says, "A bad owner grows weeds, a good owner grows rice, a clever owner cultivates soil, a far-sighted owner brings up an employee". The ideology of quality, which the society should be concerned about, is precisely targeted at upbringing employees. It means that it is a far-sighted policy.

And what do we mean by quality? The generally recognized concept of quality was formulated in **GOST R ISO 9000 – 2015**, the National Standard of the Russian Federation. Currently, its reads, **"The degree of compliance of the assembly of the object inherent features to the requirements"** Moreover, the "inherent feature" must be a constant sign for the quality carrier, be it an object or a product. A requirement is "a need or expectation that is specified. It is generally implied or it is obligatory". The term "quality" can be used with such adjectives as "poor", "good" or "excellent".

It means that the concept of "quality" can be applied to any products, goods, services and actions. The quality of products or goods can obviously be assessed more specifically, if products or goods have such measurable features as capacity, size, physical and mechanical properties, service life, and many others. All household appliances, electronics, computers and cars are selected on the basis of technical performance. Sometimes people say, "Beauty arises in the eye of the beholder", i.e. quality is perceived by each person in their own way. Dr. E. Deming noted that Quality Management does not mean perfection. It means manufacture of products that meet expectations of the market in their quality.

In the philosophical sense, quality expresses the integrity of the object, its inner certainty and specificity. Quality is directly related to economy, therefore, the economic aspect of quality plays a decisive role. However, the social aspect is equally important. It embraces the level of education, intellectual development and well-being. At the same time, the social level of people impacts the quality of their work.

We should underline the moral aspect of quality, which is associated with development of the individual, the level of self-expression and morality.

Economy – Personnel - Quality

We cannot fail to notice the tendencies of modern production development, which are based on information technology, automation and robotization. These trends will lead to qualitative changes in the management system of production processes. As a result, such work positions as production supervisors and workshop foremen will gradually cease to exist.

The article of Yuri P. Adler and V.L. Shper, Russian experts in Quality Management, convincingly demonstrates that the upcoming 3-rd industrial revolution will require the transition from the person – performer, "cog in the wheel", to the parson-creator [1, p. 38]. The new industrial revolution will need employees who are able to undergo quick retraining, learn new things, change stereotypes of their behavior. These employees need solid knowledge and broad vision.

We should also be aware of requirements for specialists during their certification. Functions of specialists-creators in engineering and technology are significantly broader than job functions described in professional standards, The latter are related to production foremen. This is clearly demonstrated in the article of Professor V.S. Gryzlov, city of Cherepovets [2, p. 43-44].

Currently, the task of universities is to ensure that the national economy has employers who will contribute to its modernization and further development. According to "Russia in Figures" statistics digest, in terms of industrial production growth, Russia lags behind several developed countries (See Table 1).

The data provided in Table 1 refer to production sector, resources industry and construction in their entirety. We can see that after a sharp slowdown due to the crisis and economic sanctions, these sectors of the national economy demonstrate growth, which began in 2016. However, as Academician A. Aganbegyan stated (see above), much needs to be done. The 2017 Investment Forum emphasized that the share of innovative products in Russia does not exceed 9% (A. Kudrin's speech). This proves, that in order to change the situation, the national economy needs trained employees.

The developed countries see the tendency of labor resources flow from material production to the spheres of services, education, civil service, transport, construction, etc. According to the 2013 data, the employment structure of the US population is represented by the following figures:

- the number of employees in the industrial sector was less than 15%;
- the number of employees in agriculture was about 3%;
- over 80% of the working population were employed in service sector and intangible production [3, p. 135].

Based on the same statistics digest, the structure of labor resources distribution in Russia from 2002 to 2015 is presented in Table 2.

As can be seen from the data above, over the recent 15 years Russia also experienced a decline in employees involved in industry and agriculture. And in which spheres of economic activity do we see the increase in employees? As in many countries, this trend is observed in the service sector. It should be reminded that all spheres of economic activity, except for industry and agriculture, belong to the service sector. In Russia, the transition to market economy gave rise to the new service sectors, which primarily applies to banking, real estate transactions and lease.

The operation of any economy is determined by employees. Primarily, it is impacted by their professional potential, i.e. their educational level. According to the statistics digest mentioned above, in 2015, educationwise, the entire active population of Russia was distributed as follows:

Table 1. Records of Industrial Production Growth (%) across Several Countries of the World from 2015 to 2016

Russia	2015	2016
China	7,0	6,1
USA	3,0	2,1
Great Britain	1,8	0,3
Germany	1,5	1,5
Japan	0,7	0,5
France	0,5	1,0
Russia	- 3,5	0,8

Table 2. Distribution of Labour Force by Economic Activity

Activity types	Years				
	2002	2005	2008	2014	2015
Industry	22,5	19,1	18,0	16,2	15,9
Agriculture	11,7	11,4	10,0	9,4	9,4
Construction	7,8	7,5	8,1	8,4	8,3
Transport and Communications	7,8	7,9	7,9	8,0	8,0
Education	9,1	9,1	8,7	8,1	8,1
Financial Operations	1,3	1,3	1,6	1,9	1,9
Real Estate Operations	–	7,3	7,3	8,7	8,8
Government Administration	4,5	5,1	5,4	5,5	5,5
Other services	35,3	31,3	33.0	33,8	34,1

- higher education – 33 %; secondary vocational education – 45 %, including 25.8% of employees involved in training programmes for mid-ranking professionals; general secondary education – 18.4%; compulsory education – 3.4%; with no compulsory education – 0.2%.

Fig.1 demonstrates the trend of change in the number of employees with a higher education. From 2002 to 2015, this number increased by almost 10 %. However, it should be borne in mind, that since 2005, almost 50% of graduates of governmental higher education institutions received their diplomas through extramural education programmes. Thus, the percentage of recent full-time graduates amounted to:

- 53% in 2010; 52% in 2011; 51% in 2012;
- 50% in 2013; 50% in 2014; 49% in 2015.

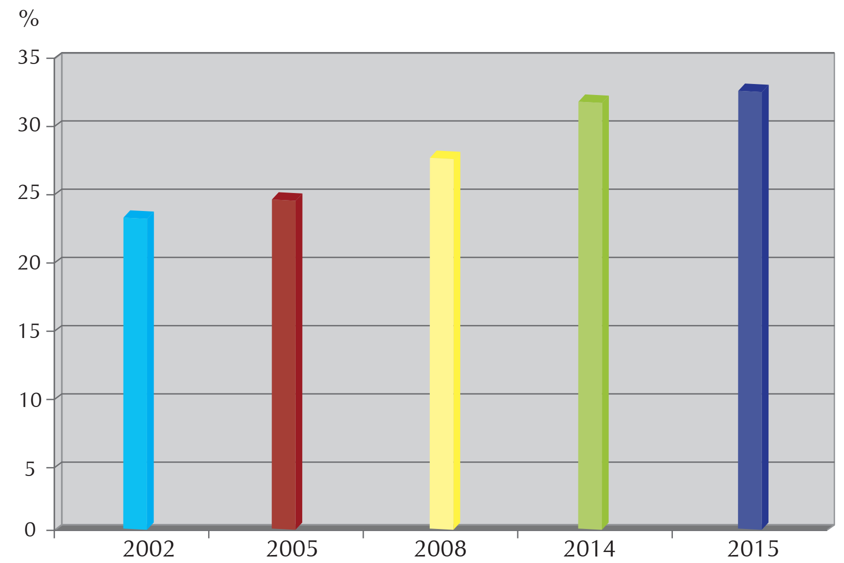
It should also be borne in mind that about 85% of graduates of non-governmental universities received their diplomas through extramural education programmes.

The educational level of employees in various sectors of the national economy is significantly high (see above reference data) with only 22% of those who did not receive a formal training. At the same time, despite the high level of education, in labour efficiency, Russia lags far behind other nations in almost all manufacturing sectors. In 1999, the labor efficiency in Russia was 19% compared to that of the US, and by 2015 it reached only 36% of the US level. The depreciation of fixed assets is the major reason of efficiency gap. Russia needs technical retrofitting and upgrading, which is achievable through training and retraining of workers and specialists with a secondary and higher education.

Massive training of specialists through extramural higher education programmes will hardly be efficient.

Higher education should imply the generation of the system of thought, the development of intelligence in a certain field rather than eligibility to obtain a better job position or perform certain activities.

Fig. 1. Number of employees with a higher education in oll economy sectors, % by year



This combination of skill and knowledge is called a profession.

The Russia's new economic policy triggers the change in the paradigm of higher vocational education, which means the transition from education **"for life"** to education **"throughout life"**. This is related with several contemporary social processes taking place in Russia. Primarily, these processes include:

- significant changes in production processes and, as a consequence, changes in professions and specialties;
- increase in the role of horizontal mobility of employees in the course of their career development;
- decentralization of economic responsibility and responsibility for product and service quality;
- change in lifestyle at all levels, such as social, organizational and individual;
- use of "managerial" approaches in vocational education management;
- increase in the dynamism and uncertainty factor;
- increase in the role of personal deve-lopment ("skills for life") [4, p. 50 - 51].

The acquisition of new socio-economic experience requires new approaches to training specialists, as the most dynamic participants of economic transition.

Bachelors or engineers?

The analysis of the ten-year experience of Bachelor's training programmes in technical fields and the subsequent employment of graduates lead to disappointing conclusions. In transition to the level training system of specialists in various fields, it was expected that at the first level, i.e. Bachelor's degree programme, trainees would receive a "broad" education and would be self-dependently employed. It was also expected that specialty training would be conducted by employers and possibly, with the involvement of the education organization. However, this did not happen! Employers need graduates prepared to perform work for a specific job position, although the graduate is just a Bachelor with no practical skills.

However, in the near future, the training of Bachelors in technical fields will hamper the development of modern innovative economy.

First of all, this will manifest itself in science-intensive industries and in industries with complex production units in such sectors as metallurgy, chemical production and complex technical facilities, which include rocket engineering, shipbuilding and aircraft construction. In our opinion, the return of engineering training to organizations of higher education is the time imperative.

The growth of the national innovation-based economy requires specialists with a key competence, which is the "commitment to quality". In our opinion, in order to train modern engineers, it is needed to solve at least two tasks:

- to develop the plan of continuous preparation in Quality for each technical field;
- to introduce elements of Quality Management System (QMS) in edu-cational process and demonstrate students the results achieved. It is desirable to involve students in QMS activities, which cover correction of inconsistencies and preventive actions. Additionally, it is necessary to identify satisfaction level by educational process participants.

To solve the first task, it is appropriate to review goals of each discipline and determine, whether they are related to product quality. In accordance with this, it is required to make adjustments to the content of educational disciplines. In addition, teachers, primarily of graduate departments and developers of special courses, need to study professional standards for potential job positions of graduates. After all, it is achievable to train students to perform relevant job functions, and to some extent job actions, efficiently using all types of practices.

Professor Yu.S. Karabasov, President of the National University of Science and Technology MISIS (NUST MISIS), in his review of our book "Education for Innovative Economy" outlined the task of university teachers as follows, "Currently, there is no issue with what to teach our students. The main issue is how to teach, in order to achieve the result, which is the product of graduates' professional and cultural competencies".

It is known, that education is a dual process involving two parties: a teacher and a student. In modern educational process, their relationships change. They are based on external and internal goals of education system. External goals are those, which are anticipated by the state and society, by means of organizing and funding education system. These goals are associated with further involvement of graduates in the economy development and, ultimately, with improvement in people's quality of life. However, we should not forget about internal goals either, which are associated with satisfaction of students with their "growth" in the eyes of their relatives and people around them, inclusive of their teachers. Internal goals also concern teachers' satisfaction with their significant work for the entire society and teachers' status.

The goal of studies changes, i.e. students need not only knowledge, because it is their intermediate goal, but also professional skills. It means that through knowledge students obtain their professional skills. The content of independent work changes and includes not only an independent study of teachers' material, but also an active and dynamic acquisition of the entire complex of issues, which arises from the ultimate goal of training formulated in the competence model.

Teachers' impact on students is required for the generation of professional consciousness of specialists that are required by modern society.

Ancient Greeks used to say that "the ship will not sail with the wind if the skipper does not know the final destination".

For the system of higher education, the requirements for future specialists belong to the "final destination". Currently, such requirements cover graduate competencies formulated in the Federal State Educational Standard and the educational programme. These are precisely the "inherent features" of our products. Graduates are expected to have "features" of their competency, which differ in breadth, depth and ability. However, they are not expected to be below the established level of future professionals being moral, purposeful and responsible members of our society.

We believe that education is "climbing up" a wide staircase, for at each step, i.e. semester, students study several interrelated disciplines. These are horizontal relationships. This transition is followed by the next step, which implies the beginning of "consumption" of previously acquired knowledge and skills. These are vertical relationships, which are connected with horizontal relationships of this step. Similarly, students use the knowledge acquired in secondary school. In addition, we must take into account that academic disciplines are taught by different teachers.

Long-term experience confirms that training of specialists in higher education establishments will be rewarding if all academic disciplines are interrelated in content. They should be arranged in the curriculum to ensure not so much the accumulation of knowledge by students as the continuously improving ability to solve various problems through the synthesis of knowledge.

In any educational programme, academic disciplines differ not only in content, but also in the required acquisition level. It is advisable to consider them as learning objectives. B. Bloom identified six levels of learning goals, which include knowledge, understanding, application, analysis, synthesis and evaluation.

To describe education results in accordance with levels of goals, we will use active verbs:

- **knowledge** – to reproduce, tell, formulate, etc.;
- **understanding** – to classify, recognize, etc.;
- **application** – to demonstrate, solve, etc.;
- **analysis** – to calculate, estimate, etc.;
- **synthesis** – to contrast, plan, etc.;
- **assessment** – to discuss, express judgment, etc.

In order to establish relationships between education results and future professional activities, it is appropriate to generate a certificate for each key competence. Table 3 exemplifies the certificate of generalized competence named "To Manage Production Process". Manifestation signs of this competence in professional activity belong to its important element. The contrast between generated specific competences and manifestation signs of generalized competence make it possible to determine training orientation of each discipline, implementation of projects, course research work and implementation of practical training.

At present, educational organizations and individual teachers have the latitude to select educational technologies, which is beneficial. However, there is a danger that we might not take proper advantage of this opportunity, due to insufficiently high and somewhere even low technology competency of teachers.

What precludes educational organizations from providing the required training quality of graduates that would satisfy consumers?

In our view, the key reasons include:

- insufficient input level of prospective university students, primarily in mathematics, physics, chemistry and drawing;
- performance of students during their study. Specifically, it is absence from university and falling out of the disciplinary system;
- low motivation of students to achieve a high level of knowledge, skills and competencies in a selected profession;
- insufficient knowledge of contemporary teaching methods by teachers;
- educational institutions are insufficiently provided with contemporary learning technologies;
- inconsistency between customers' requirements and educational programmes.

How can we ensure quality education for graduates?

Training is not a walk in the park or a show. It is hard work, which involves two participants of educational process: the teacher and the student. Universities have

Table 3. Competence Certificate

Competence	Competence Manifestations	Elements of Education Process	Generation Procedures
To manage production process.	1. Understands the essence of production process. 2. Reveals inconsistencies. 3. Determines management actions. 4. Corrects process. 5. Evaluates object reaction to external actions. 6. Understands consequences of decisions made. 7. Trains personnel.	1. Disciplines (list of disciplines). 2. Practical training. 3. Course research work.	Lectures / Practical sessions. Laboratory classes. Practical training. Trainings. Engineering games. Intellectual games.

competitive admissions because not every young person can cope with this challenge. In our opinion, Russian organizations for higher education are locked into patterns, their activities are tied by limitations. In order to "spread the wings", national universities needs to look around, evaluate their performance and ask themselves, "Are we doing everything we can to achieve the goal, which is to provide the quality education?"

In this article we cannot consider all possible types of educational technology. Some of them are presented in the work book [5, p .126 - 136]. However, we would like to focus on major approaches to the system of education and upbringing.

First, the situation with training quality of university graduates will dramatically improve if **retaking exams and tests is repealed** nationwide. It is required to introduce the system of recurrent education. Possibly, students will have to pay tuition fees and previously settle the matter with drafting in the army.

This will require changes in the State educational standards in terms of restricting duration of educational programmes. These restrictions must be withdrawn.

It should be noted that many countries have been using this education system pattern for many a year.

Secondly, the issue related to students, who combine their studies with work, can be successfully resolved if the system of **duplication of all (day and evening) training sessions** is in place. Students are expected to choose time of their studies and attend all their classes.

This will require an increase in budgets of universities. At the same time, university management "will be compelled" not on paper, but in real life **to reduce classroom hours and strengthen independent work of students.**

Third, teachers' capacity will be used more efficiently if students are taught in classrooms and their number is limited to 25 people to a group. It means than that classes are not to be divided into lectures, seminars and practical sessions [6, pp. 3-4].

This implies a significant reduction in batch lectures except for humanities lecture sessions. It would require additional human, financial and information resources. However, this system of educational process will immediately enhance the level of students' performance, especially in such "difficult disciplines" as higher mathematics, physics, chemistry, material sciences, electrical engineering, physical chemistry, strength of materials, analytical mechanics, etc.

It is no coincidence, that numerous leading US universities have this teaching method in place.

These and other proposals appear in publications, but, unfortunately, are never discussed, as if unnoticed.

We believe that it is required to focus on one more issue. Russia has launched the campaign on developing Professional Standards (PSs). The Professional Standard of Teachers was approved, however, in order to execute educational activities at universities, relevant PSs surprisingly do not contain the requirement for pedagogical qualification of teachers. In practice, most teachers, especially members of major departments, do not have a teacher education.

Back in Soviet days, this drawback was eliminated through the system of refresher training. For example, all teachers of the Moscow Institute of Steel And Alloys attended refresher courses in teaching. Refresher sessions were performed by members of the Centre for Studies. Below are the excerpts from the training package:

- Elements of Pedagogical Communication in Educational Process delivered by Academician I.A. Zimnaya, the Russian Academy of Education.
- Implementation of University Active Teaching Methods Into Practical Use delivered by Professor A.A. Verbitsky.
- Acquisition of Test Check Methods of Students' Achievements delivered by Professor V.S. Avanesov.
- Scientific Basis of Educational Process Management delivered by Professor N.F. Talyzin.

These topics are still relevant.

Conclusion

During the President's news conference on December 23, 2016, V. V. Putin said, «First, the authorities and businesses have joined efforts to adopt the National Technology Initiative, as you know. We are drafting a comprehensive economic development plan to 2025»

However, the question is, "Will the human resources be prepared for the real economic development? Is this part of the development plan?"

In our opinion, to ensure a sustainable innovative growth of Russia's economy, it is required:

- to determine priority fields of economic development and universities' schools of sciences, which are capable of providing education rather than simply training specialists;
- to allocate targeted funds for scientific and educational activities of these schools, without stretching funds across universities;
- in some universities, to extend training duration in priority fields; to increase the level of requirements for graduates, to deliver students from "retention pressure";
- in priority fields, to bring into force the State employment guarantee for graduates and lend them material support after their graduation;
- to assess competence level of students and qualification of teachers by independent experts;
- to examine the quality of extramural students' training in technical fields. If the level of preparation is insufficient, it is required to equate it with advanced training.

The national system of higher education needs fundamental reforms. It is wise to take advice from G. Ford, "Failure is only the opportunity more intelligently to begin again".

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The Mission of Competencies in Quality Management Discipline as a Part of Master's Programme "Civil Construction"

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Abstract

The article describes the role of competencies in mastering quality management discipline as a part of the master's degree programme "Civil Construction". The competencies are analyzed in accordance with the Federal State Education Standard 3+. In addition, the article presents the methodological bases of "Quality Management" discipline.

Key words: quality management, professional competencies, education programme "Civil Construction", teaching techniques, discipline content.

Under modern conditions, each economic entity is dependent on the numerous factors of internal and external environment. Under such circumstances, to ensure effective performance and prosperity, an enterprise should constantly explore the options for ensuring its development, leadership and competitive advantages. In this context, the most important task for a company is to produce high-quality products that meet both evident and latent requirements. The latter is often hidden and unconscious.

This statement is proved by the current National Standard ISO 9000-2015 that describes the fundamental concepts and principles of product and service quality as an ability to meet the consumers' needs via intentional or unintentional influence on the corresponding interested parties. In this context, the quality of products and services includes not only performance of functions according to the intended purpose and characteristics, but also consumers' value and benefits [1, p. 2].

Based on the above-mentioned, it is obvious that there is a need for the experts focused on ensuring quality both of products, technological processes and all aspects of interaction with the interested parties.

Modern education system is rooted in competency-based approach which implies that each discipline is an important stage in shaping the required graduates' competencies and skills.

In accordance with the Federal State Education Standard of Higher Education (FSESHE 3+) for the master's degree programme 08.04.01 "Civil Construction", the graduates should gain knowledge and experience in the following domains:

1) Innovative, research and design.
2)) Engineering and manufacturing.
3)) Research and teaching.
4)) Project management.
5)) Professional expertise and normative-methodological [2, p. 3].

While designing and implementing master's degree programme, a university is focused on the certain types of professional activity a master student should get familiar with according to the labor market needs, research and technological facilities of the enterprises.

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A graduate who has completed the master's degree programme "Civil Construction" should acquire a number of cross-cultural, integrated professional and professional competencies that include: PC-14 – ability to adjust modern quality management systems to certain manufacturing conditions on the basis of the international standards.

This competency can be acquired by completing the discipline "Quality Management". In this context, a student should fulfill the following triad of requirements (Fig. 1).

Obviously, independently of the functions and sphere of their application, future specialists should possess relevant knowledge and be able to apply it in their professional activity within the following domains:

- the role of quality in the construction company management;
- compliance of modern organization with the bases and principles of the overall quality management;
- the content of the approach to managing quality on the basis of the international standards;
- fundamentals of creating effective quality management system at construction companies;
- responsibility for construction works and development of optimal conditions for the most complete satisfaction of consumers' requests, needs and expectations.

These requirements indicate the importance and significance of the competences related to the quality management, especially within the master's programme "Civil Engineering".

In view of the foregoing, table 1 presents the recommended content of the discipline "Quality Management" delivered within the master's programme 08.04.01 "Civil Construction" [3, p. 2-3]

According to the curriculum of "Quality Management" discipline, lectures and practical classes are the basic teaching formats.

Lectures are recommended to deliver in a traditional format supported by Power Point presentations.

To ensure effective discipline mastering and enhance students' cognitive activity, it is recommended to use active teaching techniques

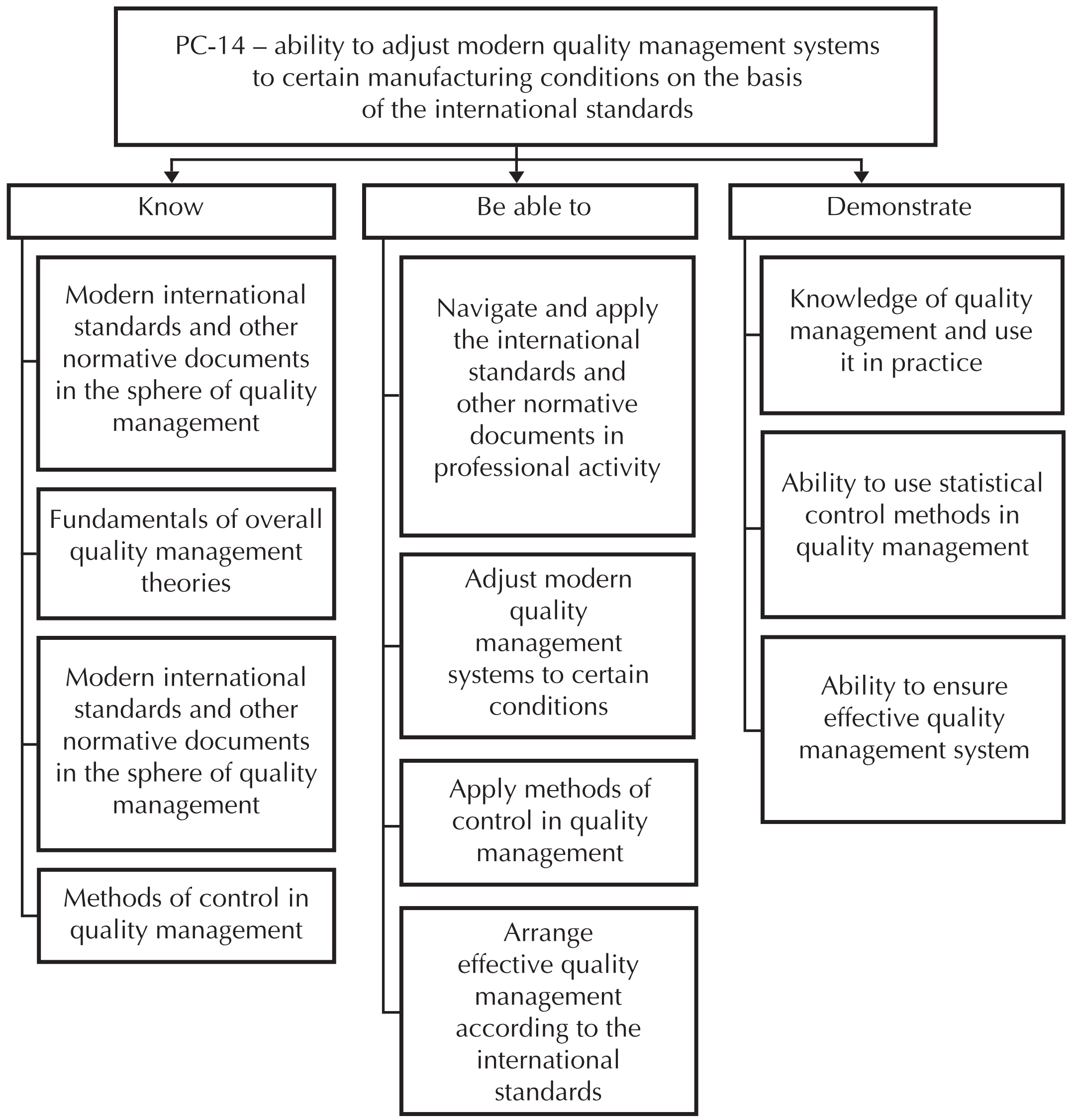
For example, within the lectures master's students could be asked to express their opinions on the discipline being taught via the "name-quality" method. The essence of this method is that a student writes a term, for example "quality", and a word or word combination related to this notion against each letter of the given term. It is recommended to use this kind of task in a systemic manner, i.e. at the very beginning of the course – to refresh the available knowledge; in the middle of the course – for interim assessment; at the end of the course – to assess residual knowledge. In addition, there is an opportunity to monitor any positive changes in students' knowledge of the terminology and discipline nomenclature, to assess a real knowledge increase. Besides, students might be given the tasks to match the terms and definitions at the end of each lecture.

The practice classes within "Quality Management" discipline are recommended to arrange on the basis of traditional and modern teaching techniques.

Most students are enthusiastic about and interested in practice classes organized as a group discussion, i.e. one of the active teaching techniques. This teaching format allows master's students to debate together the issues, ideas and suggestions related to the given task, complement each other or defend their opinions. This teaching technique is recommended for the following practice classes: "Fundamentals of quality management", "Standardization in quality management system", "Compliance conformation and quality management".

Another active teaching technique that can be applied in the practice classes of "Quality management" discipline is a

Fig. 1. Learning outcomes of the discipline "Quality Management" within competency PC-14



research-based teaching method which implies independent students' search activity. For example, to consolidate the acquired knowledge within the module "Quality as an object of management", students are asked to assess the quality of construction products of various companies. In this context, students gain experience in formulating their points of view and arguments. The algorithm of shaping the competency PC-14 within the discipline "Quality management" is given in fig.2.

To consolidate the knowledge of "Statistical methods of quality management control", master's students could be asked to prepare the presentation that would describe the algorithm of using statistical methods to monitor a certain construction process. Such task is aimed at enhancing students' independent work, developing logic and

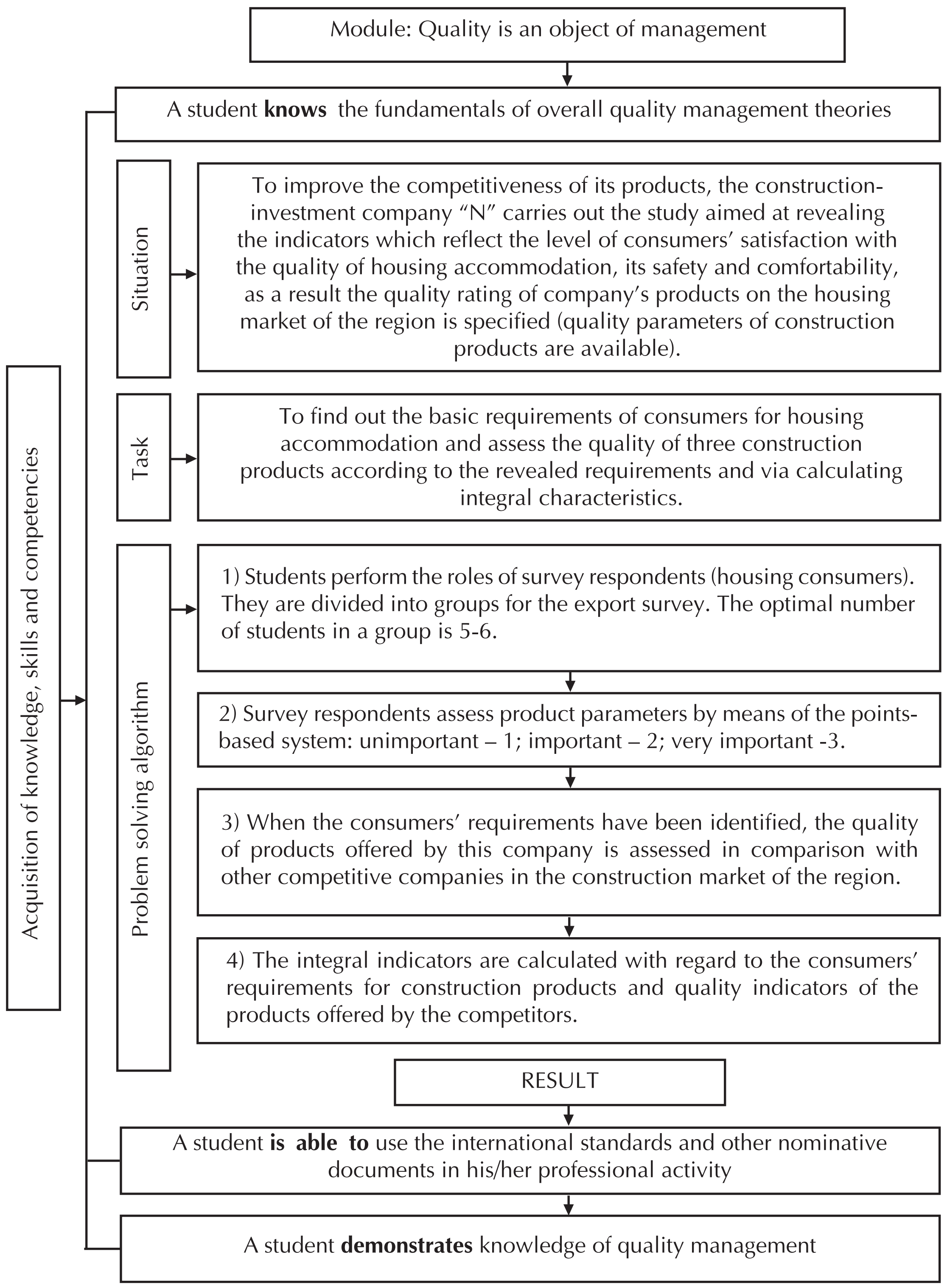
Table 1. Brief description of "Quality management" discipline modules aimed at shaping competency PC-14

№	Discipline module	Content of discipline module
1	Quality as an object of management	Methodology and terminology of quality management. The classification of product quality indicators and characteristics of basic quality indicator groups. Basic conditions and factors that affect the quality of products. The key principles of systemic quality management.
2	Fundamentals of quality management	Systemic approach to quality management. Russian and foreign experience in quality management. General approaches to ensuring quality. Quality management in civil construction.
3	Product quality control system	Basic methods of product quality control. Engineering control system. Product quality control system in civil engineering.
4	Statistical methods of quality management control	Statistical methods of quality control. Statistical methods of quality management.
5	Budgeting of quality assurance	Budgeting peculiarities of quality assurance. The concept of cost and benefit analysis in terms of quality management. The development stages and quality costs.
6	Standardization in quality management system	The notion, goals and functions of standardization. Objects and methods of standardization. The system of standardization nominative documents. Types of standards. Engineering regulative documents and technical conditions in standardization. Russian and foreign standardization companies. Standardization in civil engineering.
7	Compliance confirmation and certification fundamentals	Goals and principles of compliance confirmation. Types of compliance confirmation. Certification system of the Russian Federation. Certification in civil construction. International certification.

reasoning skills and helping students apply theoretical knowledge in a real situation [4].

The use of active teaching techniques for delivering "Quality Management" discipline is an effective way to enhance the teaching process of students pursuing master's degree in "Civil construction" education programme 08.04.01 as they help students develop the required competences and skills that allow them to design, implement, maintain and improve quality management system in the framework of a modern construction company.

Fig. 2. The algorithm of shaping competency PC-14 within the discipline "Quality management"



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UDC 378

Humanitarian Meanings of Engineering Activity and Their Actualization Among Students During University Education Process

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Abstract
In modern education, the issue related to acquisition of axiological basis of engineering activity is still solved in compliance with knowledge approach. The authors substantiate the potential of integrating humanitarian and technical components of education content through activation of psychological and pedagogical mechanisms of meaning-making. This makes it possible to establish a meaningful axiological attitude among students - future engineers, to lay humanitarian meanings and values at the basis of their professional activity.

Key words: engineering education, meaning making, pedagogical hermeneutics, humanitarian senses of engineering activity, meaningful value-semantic position.

The higher the level of technical and technological perfection of society, the more important is the degree of understanding by engineers of the meaning of changes, which their activities bring to the modern world. Today, the words of N.A. Berdyaev, "The question about technology has become a question about the fate of man and the fate of culture" [1, p. 147] become more relevant.

The question about technology has become for us a spiritual question, a question about the fate of man, about his relationship to God.

In the age of constantly accelerating scientific and technical progress, the role of engineers exceeds the limits of transformation ways of man's interaction with nature. This role has an increasingly tangible impact on public life. Thanks to modern information and communication technologies, the sphere of social communications has developed new spaces. Management processes in life-support systems of production, economic and social complexes are impossible without technological innovations.

Modern biotechnologies can not only significantly prolong human life, but also prevent formerly incurable diseases. In everyday life, in various situations, people pursue their actions through the use of modern technical devices. The main trends of modern technical innovations, such as machine learning, the development of personal digital devices including 3-D printers, “smart things”, “smart medicine”, automation and self-controlled devices, personal means of energy production, algorithmic design, etc. are user-oriented and can radically change the quality of life.

In general, we can state that there is a snowballing advance of engineering achievements into sociocultural reality. Today, engineers are actors of social transformation. Through their activities, engineers ensure the practical implementation of the most important humanitarian values. First of all, it concerns life and health of people, their comfort and safety, which affect personal well-being, social integration and creative activity of modern people. As O.D. Garanina states, “In the technical society, the engineer becomes a key figure not only in the spheres of production and economy, but also in the regulatory and spiritual spheres of society” [2, p. 99]. As the engineering influence extends and penetrate all new sociocultural processes and interactions, the humanitarian component of modern engineers’ activity becomes increasingly important. According to V.M. Rozov, it is required to include this impact in understanding of engineering and technology processes [3, p. 8-9]. Special research efforts in engineering ethics are indicative of the qualitative change in axiological orientations of engineering activity in the context of significant extension of social institutions and spheres, which can be impacted by engineers’ activities. As a result, the engineer’s fundamental standard of responsibility, which involves “profession service”, “proper operation”, currently includes the requirement for social responsibility. In addition, standard of responsibility becomes “polycentric” (A.Yu. Sogomonov) [4, p. 70]. Contemporaneously, modern engineers should entirely focus on serving the society, nature and culture. Therefore, axiology and reliance on humanitarian meanings become the most significant features of engineering activity.

The requirement for meaning orientation of engineering education, noted by Yu.P. Pokholkov and B.L. Agranovich, plays an important role. According to the above-mentioned scholars, “To become professional engineers, students must leave the space of knowledge and enter the space of activity and life meanings. Knowledge and methods of activity must be combined into the organic integrity, which system-forming factor consists of certain key values” [5, p. 8]. In accordance with these ideas, at the stage of university training, it is required to strengthen the personal orientation of educational process and, first of all, to increase the meaningfulness of students' axiological stance. It is also required to create conditions that would allow students to understand the axiological basis of their professional activity, to place humanitarian meanings into consciousness of future engineers, These are “really acting” rather than “known” motives (A.N. Leontiev), which would perform activating, directing, regulative and meaning-making functions with regard to professional activity. The problem is that in order to achieve this goal, the traditional approach to constructing the education content is not sufficient, since it is required to offer students not only a vast array of humanitarian knowledge, but also to contribute to interiorization of values.

At present, the national and international engineering education is mainly represented by versions of interdisciplinary integration of its humanitarian and technical components by the principle of complementation. These components include the reinforcement of educational programmes in technical fields with humanitarian topics and projects (K. Chau, P. Christensen, X. Du, N. Dubreta, M. Lehmann, M. Thrane, R.W. Welch (Denmark, USA, China, Croatia), integrative training courses, which combine humanitarian and professional units (G.V. Panina, A.S. Sokolov, L.V. Yuzhakova, A. Agogino, C.T. Hendrickson, H.S. Matthews, M.W. Bridges et al. (Netherlands, Australia, USA, Russia, etc.), integrative educational programmes (H. Blottnitz, D.M. Fraser, R.C. Hudspith, F.J. Lozano, O.M. Zamyatina, M.V. Lychayeva, P.I. Mozgaleva et al (Canada, South Africa, Russia). At the same time, modern national and international regulatory documents, such as CDIO, ABET, professional standards, FSES, the description of qualities of modern engineers include the ability to take a holistic approach to solving professional tasks. This implies a deeper integration of meaningful and professional-practical aspects of engineers’ activity. For the design of engineering education content, the idea that “the harmonious unity of natural-science and humanitarian culture of cognition and activity, the unity based on mutual understanding and dialogue is the axiological feature of engineering education humanitarization" plays an important role [5, p. 8].

The integration of humanitarian and technical components of education content based on meaning-making mechanisms, which ensure the transformation of educational, scientific and technical information into personal meanings, is a productive way of reinforcement of axiological orientation in training of modern engineers. Unlike "impersonal" information, personal meanings, or "living knowledge" (G.G. Shpet, V.P. Zinchenko) have been lived through and are internally accepted by individuals as a value. These personal meanings act as regulators of practical activity. In the context of the proposed problem, modern studies of regularities and ways of actualizing the meaning-making in the learning process (I.V. Abakumova, E.G. Belyakova, I.A. Rudakova), the ideas of pedagogical hermeneutics and methods of text interpretation as the means of developing personal meanings (A.F. Zakirova) are of interest. The mechanism, which assists in penetrating into humanitarian meanings of engineering activity, is based on developmental potential of textual activity, where the multilateral understanding of the subject and humanitarian content of technical information takes place. This activity is also accompanied by understanding its meaning in the context of the unity of culture, nature, society and man. The integration of humanitarian and technical content components of engineering education is implemented through the synthesis of various ways of understanding information, such as cognitive (mental) and interpretational. The latter are based on axiological relation to the subject of understanding. Ways of understanding information are mediated by personal values. The axiological stance, which in the course of professional activity is a decisive subjective factor for making responsible decisions, is the result of integration.

In line with these approaches supplemented by concepts and technologies of contextual training (A.A. Verbitsky), the technology of humanitarian meanings development in engineering in the context of university education (A.A. Melikhova) was established. Along with technical and humanitarian texts, this technology involves the use of special "humanitarized" technical texts. Their understanding requires both cogitative activity for the analysis of their subject content and the interpretation of humanitarian meanings, which reflect value aspects of engineering activity.

Actualization of humanitarian meanings of texts takes place in the form of the "multiangle" hermeneutic dialogue, which makes it possible to reveal the meanings in correlation with personal, sociocultural, meaningful and professional contexts. The work with technical texts is a stagewise process. It involves 1) the actualization of humanitarian meanings in the context of professional activity, 2) the understanding of subject and axiological content of "humanitarized" technical texts, 3) the "humanitarian translation" and interpretation of technical texts, 4) the projection of humanitarian meanings in practical engineering activity in simulated or real professional situations.

This technique was successfully tested at the Tyumen Industrial University and involved 110 students, 23 teachers of subject disciplines and supervisors of curricular practical training. According to the results of diagnostic cross sections, over 80% of students in the experimental groups demonstrated a significant increase in the level of meaningfulness of humanitarian aspects of engineering activity.

Let us illustrate the technique of humanitarian meanings development of engineering activity on the example of the class scenario. The subject was "Structure and Properties of Materials" as part of "Construction Materials Engineering" course, "Production Machines and Equipment" training programme. In order to actualize humanitarian meanings of engineering activity, students were offered a small video clip with an overview of technical and humanitarian causes, conditions and effects of the world's largest derailment of the inter-city express train near Eschede, Germany, in 1998. In the course of dialogue and subsequent discussion, students vividly realized that the results of engineering activities, in this case connected with adequate and timely testing of materials, directly depended on human factor. Negligence in the use of materials, improper maintenance control, neglect of safety techniques, inattention to extraneous noise led to fatigue of metal and microcracks and, ultimately, caused the catastrophe. In addition, the company's striving for immediate profit and reluctance to come to a well-planned, but postponed result associated with costs of modernizing the fabrication technology of electric train wheels, in their totality caused one of the world's largest rail accidents. At this stage, it is very important that students not only understand, but also emotionally feel the gravity of the engineer's role in this situation.

At the stage of object and axiological comprehension of "humanitarized" technical texts, the teacher's lecture dedicated to properties of structural materials was the method of submitting the material. The lecture was enriched with humanitarian accents and supplemented by appeals to personal experience, examples from history, illustrations of real objects and their application in Russia and abroad. This made it possible to attract students' interest to the diverse role of the engineer, emphasize the humanitarian side of their activity, make the material more open to dialogue during its further discussion. For example, "The development of biofuels, solar energy, optoelectronic devices, pharmaceuticals, medical studies for analysis of different samples, which include designed nanoparticles, nanostructures, biological polymers, cells of plants and tissues, play a significant role in the growth and well-being of society. It was exactly the goal that stood before Laurene Tetard and other researchers from Florida, USA, when they developed the photon-nanomechanical force microscopy method. Based on the analysis of vibrations produced by exposure to light waves of different lengths", this method determined mechanical, chemical and physical properties of materials. This diverse content of the lecture provides the basis for multi-contextual comprehension of technical information with its relation to the human personality, society, eco-cultural and natural environment, medicine and history.

At the stage of interpretation and "humanitarian translation" of technical texts, students were offered a task that contained both technical and humanitarian aspects. Students were to (1) prepare technical descriptions, formulae and calculations on "Mechanical Properties Detected Under Static Loading: Tensile Tests (Elasticity, Strength, Plasticity), Hardness Tests (The Brinell, Vickers, Rockwell Method), Fracture Toughness Tests: Tests At Dynamic Loading: Tests On Impact Strength, Cold Resistance Tests; Tests Under Cyclic Loading: Fatigue Tests"; (2) identify humanitarian problems in the topic under study, such as examples of human participation in this process, possible negative risks, capabilities, hazards and benefits.

The results demonstrated that with appropriate formulation of the task based on preliminary work on actualization of humanitarian meanings of engineering activity and understanding "humanitarized" technical texts (Stages One and Two), at Stage Three students could independently identify a wide range of relevant humanitarian aspects of engineering activity in the context of studied material. For example:

- according to NPO Saturn, Russian aircraft engine manufacturer, testing of thermobarrier coatings with low thermal conductivity under TheBarCode project, enhances the efficiency of energy production and reduces fuel consumption in aircraft engines. Ultimately, it has a significantly favorable effect on the environment;

- disasters associated with untough tests for metal fatigue. For example, the negligence of pilots to landing technique led to the crash of the Antonov-10 aircraft near the city of Kharkov, Ukraine, in 1972. Also, the violation of occupational safety and health rules led to the accident at the Sayano–Shushenskaya Dam in 2009. As a result, it caused environmental pollution, loss of life, panic and economic damage. The priority of financial issues over the value of human live led to the bridge collapse at Pushkino station, the Moscow Railway, in 1999. The bridge collapse caused loss of life and injuries;
- the socio-cultural aspect involves problems of cold-resistance testing of materials, which are relevant for Yakutia, where people and animals live in low-temperatures and life of plants stops;
- solid bodies of vehicles made of steel manufactured by Nippon Steel, Japan, can provide a greater security for passengers. This steel can withstand mechanical pressures up to 1,470 MPa. Additionally, in comparison with alloy steel, it is lighter and less expensive;
- increased crack resistance, hardness, plasticity, high operating temperature and other properties of nanocomposite materials developed for extreme conditions of space and nuclear energy will allow people to go beyond their capabilities in the future.

At the final stage, students were offered to perform tasks intended to demonstrate students' personal axiological stance in the course of making responsible decisions. Thus, it created conditions for establishing relations between humanitarian meanings and real professional and practical activity and also for reinforcement of its value-based mediation. In developing the catalogue for practical application of the non-sample method and its advantages based on the generalized analysis of other basic methods, students generated written reports. They included traditional for this work technical descriptions of the non-sample method as the most economical and simple. The reports also contained conditions and scope of method application, operating principles of the portable device and strength tests of material. In their oral presentation dialogue on the subject "Social, Psychological, Economic, Environmental and Other Issues of Non-Sample Control Application in Comparison with Other New Methods that Require the Use of Samples", students displayed the humanitarian aspect of the task to be solved. For example, they managed to identify advantages of the non-sample method, which in their view, complied with significant humanitarian values and meanings of engineering activities. The advantages included non-destructive effect on technical objects, fast evaluation in emergency situations, minimization of harmful effect on the environment, population and personnel due to the lack of large production facilities, capability of automation and preservation of human resources during remote control, the capability to determine hidden deformations to exclude human error, provision of universal security, application in difficult weather and natural conditions and non-standard situations in such spheres as aviation, space, nuclear power, shipbuilding, etc.

At various stages, work with scientific and technical texts can involve methods of contextual learning, which make it possible to simulate the real professional context, including business games, socio-technical design and socio-cultural analysis of production situations. To activate meaning-making, such interactive methods as dialogue, polylogue and discussion are the required forms of conducting classes. Technology can be employed system-wide in the course of teaching social, humanitarian, natural science and professional disciplines, thus ensuring its high productivity.

To summarize, we emphasize that due to the growing role of modern engineers in improving life quality of people, the meaningfulness of professional activity, the reliance on value consciousness, the receptivity to humanitarian meanings, the ability to project these meanings in situations that require responsible decisions belong to current issues in the course of training modern engineers. The tasks of technical education include the development of students' capacity to axiological reflection of engineering activity, their readiness for constructive and meaningful dialogue in the context of differences in social interests and values.

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Interactive Unified State Exam Training Complexes

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Abstract

The article presents the experience in implementing modern interactive tools, precisely unified state exam (USE) training complex, into school education. It describes the structure of the training complex and specific features of its integrated elements. The use of USE training complex for studying History of Russia is examined.

Key words: training complex structure, motivation to study, knowledge quality.

Modern education, in our opinion, should meet two basic requirements. Firstly, it should correspond to the individual demands of every learner providing him/her with the possibility to go through his/her own learning path. Secondly, it should contribute to developing these individual demands involving learners into education process focused on the personal growth and development of the required skills and attributes. To meet the above described requirements, it is essential to use a special information-training environment (ITE).

Our concept of learning by means of ITE tools implies a variety of e-courses within each programme. Such approach allows planning and transferring comprehensive knowledge both by means of e-learning and blended learning. It also provides each instructor with the possibility to choose his/her own ITE tools and services, as well as teaching resources.

One of the relatively new elements of our e-courses is an interactive USE training complex. The training complex is intended for independent evaluation of knowledge acquisition within a certain subject including the ways to improve the results during further academic activity. The tasks of the training complex are compiled in accordance with the "Encoder of the content elements and requirements to school leavers' knowledge for the unified state exams". The fulfilment of the same tasks is evaluated by the USE.

Let us examine implementation of USE training complex for studying History of Russia. It is worth noting that the content of USE training complexes is defined on the basis of the Federal component of the state standards for school education including basic and special levels (the order of the Ministry of Education of the RF dated 05.03.2004 No. 1089) and the Historical and Cultural Standard which is an integral part of the Concept of a new teaching complex on the national history.

The training complex covers the content of the Russian History course starting from the ancient times up to the present days including the data on the world history (history of wars, diplomacy, culture, economic relationship, etc.) and is aimed at revealing learners' achievements in History. The most crucial upgrading of training complex structure was its revision in accordance with the structure of the Historical and Cultural Standards. A new structure of the training complex includes the blocks of tasks, each of which is aimed at evaluating certain set of knowledge defined by the Historical and Cultural Standards: knowledge of chronology, knowledge of terminology and concepts, knowledge of personalities, and ability to work with documents, etc.

Thus, the USE training complex is aimed at helping learners systemize knowledge, get deeper insight into History of Russia from the ancient times to the present days including the issues of world history and familiarize them with various tasks used in the Unified State Exams.

It is worth noting that each USE test version includes significant amount of factual material. At the same time, great attention is paid to evaluating analytical, informative, cognitive and other intellectual skills of a learner. Due to the indicated binarity of the USE test content, the training complex on History of Russia is divided into two parts.

The first part consists of 21 blocks which cover in chronological order all didactic units of the USE encoder. The content of History of Russia is embedded into the training complex in a clear and concise manner – in the form of structural-logical schemes and tables. Such form allows revealing the most significant features of historical events and processes, identifying the regularities of and trends in development of Russia and understanding the link between definite historical events. The concise and clear manner of information delivery fosters its acquisition, enables learners to save time on material revision and enhance the preparation process for the USE.

Each training block allows evaluating knowledge and certain skills within any section of the course. The names of all training complex blocks are given in the table as an example. They cover the course on History of Russia from the ancient times to the Middle Ages and present times.

Each block of the training complex includes 20 tasks compiled according to the specific characteristics of each training block. These specific characteristics reflect more sophisticated structure of the material than that presented in the Encoder. Each element of the Encoder is subdivided into smaller topics in accordance with the content of certain tasks of the USE. Such detailed structure enables not only to evaluate knowledge acquisition within the course regarding possible specific features, but also to train various types of a learner's intellectual activities that may be useful for corresponding task resolving (Table 1).

Thus, the blocks of the first part of the training complex cover the entire history of Russia, each being devoting to a certain peculiar chronological period. The second part of the training complex includes 15 blocks, each of which covers the entire history of Russia, but is aimed at enhancing certain activity (Table 2).

It is worth noting that holistic thinking is currently becoming rather popular. It is focused on a new holistic view of history and conceptual thinking as an intention of scientific historical conscious aimed at "catching" senses in most complex cases of History of Russia.

Today, knowledge of history including its role and significance in society is becoming more and more relevant. When a modern person is asked a question "Does he/she need knowledge of History?", History should be understood in a broad sense: it is an archive of culture, first of all, national culture. It makes it possible to give a clear answer to the question: Does a modern person need to know the past history? Definitely, "a person who has lost his/her memory becomes deprived of his/her personality, so, the nation which has lost its historical memory becomes deprived of its national identity", stated A.L. Nikiforov, Doctor of Philosophy [1].

Each new generation poses its own questions to the history looking at it like in the mirror and trying to find the ways how to solve the present problems. Completing the course on National History is not only useful in terms of educational, scientific, thought-provoking aspects, but also provides learners with practical orientation. History facilitates spiritual development of personality, as well as development of historical conscious. It enables to retain and strengthen value orientation of a person, contributes to independent creative thinking and active public activity [2].

It is worth noting that training and instructional methods to study History,

Table 1. Training complex (the first part)

Name of training complex block	Activity to be evaluated
№ 1. From Ancient Rus to the Grand Duchy of Moscow.	Knowledge of basic facts, processes and events.
№ 2. Development of the united Russian State. Russia throughout 16th to 17th centuries.	Knowledge of basic facts, processes and events.
№ 3. History of Russia from the ancient times to the end of the 17th century.	Establishment of cause-effect relationship.
№ 4. Russian culture throughout the 8th – 17th centuries.	Various activities.
№ 5. History of Russia from the ancient times to the end of the 17th century.	Search for information in various sources.
№ 6. Russia during the 18th and the first half of the 19th century.	Knowledge of basic facts, processes and events.
№ 7. Nobility Imperia during the 18th – first part of 19th centuries.	Knowledge of basic facts, processes and events.
№ 8. Russian Imperia throughout the 18th – first part of 19th centuries.	Establishment of cause-effect relationship.
№ 9. Internal and external policy of Russia during the 18th – first part of 19th centuries.	Search for information in various sources.
№ 10. Internal and external policy of Russia during the 18th – first part of the 19th centuries.	Knowledge of basic facts, processes and events.
№ 11. Russian Imperia throughout the second part of the 19th century – beginning of the 20th century.	Establishment of cause-effect relationship.
№ 12. Russian throughout the second part of 19th century – beginning of the 20th century.	Search for information in various sources.
№ 13. Culture of Russia during the 18th – beginning of the 20th century.	Various activities.
№ 14. Russia, USSR, throughout 1917–1941.	Knowledge of basic facts, processes and events.
№ 15. Russia, the USSR, throughout 1917–1941.	Establishment of cause-effect relationship.
№ 16. The Great Patriotic War 1941–1945.	Knowledge of basic facts, processes and events.
№ 17. The Great Patriotic War 1941 – 1945.	Search for information in various sources.
№ 18. Internal and External policy during 1941 – 1991.	Knowledge of basic facts, processes and events.
№ 19. The USSR during 1941 – 1991.	Establishment of cause-effect relationship.
№ 20. Russian culture from 1917 until the present day.	Various activities.
№ 21. The Russian federation from 1992 until the present day.	Knowledge of basic facts, processes and events.

Table 2. Training complex (the second part)

Name of training complex block (evaluated activity)
Training block № 22. "History of Russia throughout the 8th – 21st centuries" (Ability to define the order of the events).
Training block № 23. "History of Russia throughout the 8th – 21st centuries" (Knowledge of dates; matching task).
Training block № 24. "History of Russia throughout the 8th – 21st centuries" (Term definition; to choose one element (term, name) from the list).
Training block № 25. "History of Russia throughout the – 21st centuries" (Term definition based on several features).
Training block № 26. "History of Russia from the beginning of the 20th century until the present day". (Work with the historical text. Brief answer in a form of a word, word phrase).
Training block № 27. "History of Russia throughout the 8th – the beginning of the 21st centuries" (Work with the historical text; task to match the characteristic features of the studied period of Russian History).
Training block № 28. "History of Russia throughout the 8th – the beginning of the 21st centuries" (Systematization of historical data. Multiple choice).
Training block № 29. "History of Russia throughout the 8th – the beginning of the 21st centuries" (Knowledge of historical personalities; matching task).
Training block № 30. "History of Russia throughout the 8th – the beginning of the 21st centuries" (Knowledge of basic events, processes; matching task).
Training block № 31. "History of Russia from the 8th century to the end of the 19th century" (Work with historical document; task to match the fragments of two historical documents).
Training block № 32. "History of Russia from the 8th up to the beginning of the 21st century" (Systematization of historical data presented in various forms (tables)).
Training block № 33. "History of Russia from the 8th up to the beginning of the 21st century" (Knowledge of basic events, processes; gap filling task).
Training block № 34. "History of Russia from the 8th up to the beginning of the 21st century" (Knowledge of basic events, processes of Russian culture; matching task).
Training block № 35. "History of Russia from the 8th up to the beginning of the 21st century" (Analysis of visual information based on the proposed photos).
Training block № 36. "History of Russia from the 8th up to the beginning of the 21st century" ("Reading" of illustrated historical source and matching it with a certain historical period).

including USE training complexes, are intended to provide young people with the ability to demonstrate thinking skills by analyzing, synthesizing, and evaluating historical information, to help them understand cause-effect relationship, get interested in history and acquire sense of pride for their country.

When introducing teaching and interactive programmes into education system including USE training complexes, a special focus is put on the issues and tasks which are intended to be covered by learners independently. Thus, the training complex can be easily applied both by learners for independent studying and school teachers during History classes for teaching and course refreshing.

It is to be noted that a leaner studying History by means of the training complex is given the interactive test which consists of 20 tasks, each corresponding to a certain specific topic. Each task is randomly selected from the task base according to the chosen block. The number of tasks ranges from 250 to 350, with the total number being more than 10000. As a result, teachers are equipped with numerous interactive tests that can be used both in class for group work and at home for independent study.

Depending on the specific setting, time constraints can be imposed on a test. After submitting the test, it is evaluated on a 100-point scale. The results and feedback options including all given questions and selected answers with correct ones are in effect for learners to view. When resolving the task of the second block, the answers are supplemented with the comments, which significantly contributes to the learning effect of the training complex.

To resolve the tasks of a certain training block, a learner is allowed multiple attempts. It is essential that the questions and all given answers are saved. It gives a teacher and a leaner the possibility to think over or to discuss a certain answer. In addition, each leaner has the possibility to trace the history of attempts within a certain training block, as well as to receive the final grade. In fact, a leaner may build his/her own learning path. The obtained data and results allow teachers and learners to analyze and adjust individual learning paths.

A teacher has the opportunity to view the time spent on each training block and learner's result in terms of the final score. The result of the entire group can be compared with the results of all participants presented as the histogram showing the distribution based on the received score and average score for the whole group and all participants.

The training complex is equipped with an automated service "Statistics" that provides a teacher with great amount of useful information concerning task fulfilment within each training block:

- the number of first attempts;
- the total number of attempts;
- average score of the first attempts;
- average score of all attempts;
- mean-squared deviation from the average score;
- skewness coefficient of distribution of learners by the obtained score;
- coefficient of kurtosis (a descriptor of the shape of a probability distribution of learners by the obtained score);
- task internal consistency index (a definer of result reliability);
- error coefficient (a characterizer of correlation degree for various training tasks);
- standard error of test result.

Such detailed analysis of the obtained results for each learner and the whole group allows for an objective assessment of learning outcome achievement within the selected training block, i.e. rather specific topic of the course. It also enables teachers to identify the problem questions and make the necessary adjustments to the teaching process.

In addition, "Statistics" service allows for assessment of all training block tasks providing the following data that is important for task designers:

- the number of attempts;
- easiness index;
- mean-squared deviation;
- effective weight (share of certain task in total score);
- differentiation index between good and weak learners (roughly);
- efficiency of the differentiation (more accurate indicator of correlation between the answers and the entire test).

In conclusion, it should be noted that approximately 1000 learners annually use USE training complexes, undertaking about 20000 various tests. They connect to the training complexes independently or with the assistance of their teachers. Based on the teachers' feedbacks, the following conclusion can be made:

1. Significant involvement of learners into the academic activity is registered: the increase in time and intensity, as well as importance of game forms and competition in teaching.

2. A teacher is granted with an interactive tool that allows for the increase in learner's independent work efficiency, as well as individual and group class work.

3. Use of training complexes stimulates learners' motivation to study, enhances education quality and improves the results of independent knowledge level assessment.

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Development of Creative Graphic Skills

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Abstract

The article considers the current problems of teaching descriptive geometry for engineering students at the Russian universities. The key objectives of descriptive geometry course are shown. Modern conditions of teaching the course are described in terms of Russia's accession to the Bologna process.

Key words: graphic problem, art, individual approach, extracurricular work, Bologna process.

The history of science of projecting things on a plane or surface originates in the remote past. Ancient people of not only Egypt, Assyria ... but also Yakutia drew the things surrounding them on the walls of their houses and rocks. Most often these were the drawings of animals and birds, hunting which was a source of human livelihood. For instance, nowadays there is a picture of horseman depicted on the Lena cliff that later became the State Emblem of the Sakha Republic (Yakutia).

By the end of the 18-th century knowledge of drawing methods had been highly estimated and theoretically grounded, but it was only due to French scientist Gaspard Monge (1746–1818) whose contribution made descriptive geometry a science. He consolidated all scattered data of descriptive geometry into one system and is deservedly considered one of its founders as a science.

Monge understood that it is necessary to create a rigorous scientific, mathematically strict system of graphic drawing, by means of which one could transfer spatial structures to a plane and, vice versa, represent a design appeared in an architect's or engineer's mind and depicted on a plane in a real material and real conditions. This idea based on the human ability to visualize information was rather perspective and influenced the development of higher engineering education for the next 250 years. Monge was a geometrician of wide range – the first among the greatest geometricians of the 19-th century who transformed completely this ancient branch of mathematics.

Like any other science, descriptive geometry originated in human practical activity. Being one of the geometry branches, it has the same goal as geometry in general, namely, to study shapes of surrounding real world, establishing definite regularities and apply them for solving practical problems. Therefore, descriptive geometry immediately became firmly recognised by engineering school as one of the basic disciplines of engineering education.

Descriptive geometry is a language necessary for an engineer. Its second task is "to deduce all facts that inevitably result from their shape and relative positions from accurate description of a figure. In this sense it is a means of searching for the truth, it produces numerous examples of transferring from known to unknown spheres". After that: "Public education will be given the perspective trend, if our young specialists get used to applying descriptive geometry for graphic constructions necessary in

many spheres and use it to design parts of machines, by means of which a man, using forces of nature, reserves the option to develop his mind". Descriptive geometry is a universal subject.

Modern course of machine and mechanism theory rooted from the course of machine construction, and is genetically related not to mechanics, but geometry, namely, descriptive one.

Monge's teaching methods include design of manuals on not only subjects of theoretical and applied knowledge, but also on engineering sciences, which at that time were only at the beginning of their development. In this regard Monge's essential role is connected with his role in organization of higher education on the absolutely new terms.

Descriptive geometry is a major subject among the graphic disciplines and theoretical basis for engineering design.

It is one of geometry sections, where space figures presenting a set of points, lines and surfaces, are studied in terms of their projection reflections. It is based on the projection method used to deliver images of space figures on a plane or surface.

Under the condition of modern scientific and technological progress, the necessity to have comprehensive information on a wide range of this or that area of science and engineering including the area of engineering graphics is obvious.

Ancient Greeks called human experience and skills "technique" (techne). Later on, it was also referred to the tools developed by skilled people.

Machine building, electrical engineering, radio engineering, instrument making, chemistry, oil and gas industry – all these are branches of modern engineering. To acquire knowledge and participate in their development, one should be able to accurately and clearly express the ideas by means of drawing and present them spatially using plane figures, signs, and numeric symbols.

Creative work is various, but its forms are interconnected in many aspects. For example, engineering art is inconceivable without design, as both functional quality and view of the product are important for consumers. Architecture is also assessed from aesthetical point of view. The common link connecting most types of creative work is graphic image, first of all, drawing, therefore, the drawing course incorporates great potentials to develop personal creative skills. However, application of this theory to practical problems requires sufficient development of such human skills as spatial awareness and logical reasoning. It should be kept in mind that spatial awareness is not a special gift, it is in everyone, as everyone is able to imagine a pyramid, cube, cone, parallel and perpendicular lines.

Karl Marx pointed out the fact that labour ends in some outcome that has been in the laborer's mind at the beginning of the process. "A spider performs operations similar to those of weaver, and a bee puts to shame some human architects by building its wax cells. Nevertheless, even the worst architect differs from the best bee by the fact that before building a cell, he has had it in his mind" [1].

As for logical reasoning, it is enough to have ability to concentrate, be attentive and consistent to develop this skill. To correctly design the problem solution, one needs to know the way of performing graphic construction and be able to draw them – which is not the same. Only doing regular exercises one can develop skill of correct problem solution by the descriptive geometry methods.

There are four stages of knowledge acquisition in pedagogy: understanding, memorizing, application of knowledge and solving creative problems. However, the stages of knowledge acquisition are reflected in definite activity: recognition, reproduction, solving typical problems, solving non-typical problems requiring application of skills in new conditions. Consequently, application of skills in new conditions is a necessary stage of learning.

Learning descriptive geometry requires great attention and concentration, all the more since discipline bases are mostly taught using abstract, "purely" geometric elements – points, lines, planes, surfaces, geometric bodies. Any real body has an immense variety of properties, but any science has to abstract from most of them and consider only part of their properties included in its subject. "Pure mathematics, – wrote F. Engels, – has space outlines and quantitative relations of the real world as its object, hence, – it is a real material. However, to be able to study these outlines and relations in pure form, one needs to completely separate them from the content, putting the latter aside like something neutral; in this way we will obtain points without measurements, lines without thickness and width, different **a** and **b**, **x** and **y** – constants and variables..." [2].

The course 'Descriptive geometry, drawing, and computer graphics' is one of the basic general engineering disciplines for engineering training. Besides, acquired knowledge is necessary for studying other general science and special engineering courses.

The primary objectives of descriptive geometry course are: *to study theoretical bases of projection, techniques of imaging special forms on a plane and solving the problems related to those forms in terms of their projections.*

Knowledge and skills acquired in studying descriptive geometry are one of the bases for future engineer's development. It strongly contributes to the development of spatial awareness, necessary for any branch of engineering activity.

The founder of descriptive geometry Gaspard Monge called a drawing *"a technician's language", which is an international language* equally explicit for all technically literate individuals regardless of speaking language. The logic of problem solution in descriptive geometry is expressed in the form of algorithms showing a definite sequence of graphic operations.

It is presented as a foundation for drawing. Developing this idea, the Russian scientist, graphic artist, author of the first Russian textbook V.I. Kurdyumov (1853 – 1904) wrote: "While drawing is an engineering language, descriptive geometry serves as a grammar of this international language, as it teaches us to understand other people's thoughts and express our own thoughts using only lines and points as elements of image for words".

Monge's method of parallel projection provides expressivity, conciseness of solution, reliability, visualization, high accuracy, and well-measured images on a plane, it was and is the main method of technical designs.

The course "Descriptive geometry" is traditionally regarded by the students as one of the most complicated, hard to understand courses. Learning descriptive geometry, the percent of academic performance and learning quality are always lower than for other courses. It has been well joked: "Pass descriptive geometry – you can fall in love, pass material strength – you can marry".

However, the challenges expecting students should not be exaggerated. If they have minimal mathematical culture for mark satisfactory, they will muster this subject.

To create a single European Higher Education area, in 19 June, 1999, in Bologna Education ministers of 29 European states adopted the declaration of "European Higher Education Area" at the conference.

Russia joined the Bologna process in September, 2003. After Russia's joining the Bologna process the Russian universities adopted the two-level education system – Bachelor and Master degrees, i.e. the university training period was reduced for a whole year. Bachelor degree is an incomplete higher education, being only the first stage of higher education. One should tell it like it is. People should not be misled! Master course is a main and last stage of higher education. This is a complete higher education.

Fast development of science and technology has resulted in new branches of knowledge and, as a consequence, new disciplines, which are introduced into curricula. As a result, the hours for general science curricula, which are the basis of engineering education, are significantly reduced.

For this reason, all curricula were reviewed. Moreover, whereas in the past the number of class hours was approved by the Ministry for Education and Science of the RF, now it is performed by a graduate department. University graduate departments immediately initiated the reduction of class hours for descriptive geometry without any explanation.

This tendency is observed in other institutes and departments of the university. Several departments of Mining Institute have twice decreased the hours for descriptive geometry. Whereas in the past the course took 2-4 terms, now it is studied for 1 term. In the 1950's mining students learnt descriptive geometry for 4 terms. Institute of Physics and Technology (North-Eastern Federal University) has moved even further. From the following chain: descriptive geometry, engineering and computer graphics the theoretical part was completely eliminated – descriptive geometry, leaving only engineering and computer graphics, whereas department of solid state physics deleted this course from the curriculum at all.

The recently published textbooks on the course recommended by the Education and Science Ministry of the RF for Bachelor students devote to the theory – descriptive geometry - the most minimal part in contrast to the classical textbooks published in the past (less than at the university of the Soviet time!) [3].

It is explained by a number of objective and subjective causes.

The necessity of such detailed gist of descriptive geometry in the article is mainly caused the fact that elimination of descriptive geometry from the curriculum has led to the situation when one could not speak about pedagogical bases of artistic graphics. Descriptive geometry is greatly richer than the facts described here.

It is difficult to imagine teaching Russian or foreign languages without **Grammar**. However, in case of descriptive geometry, it is possible, in the curricula designers' opinion.

The hope is that our voice for descriptive geometry will be heard by the designers of engineering curricula at Russian universities.

To sum up we use the words by NEFU professor A.A. Burtsev: "We should not train engineers who can only set a conveyor and produce consumer goods, and not architects who can design only standard buildings, and not doctors who treat not a man, but only a decease, but we should train specialists capable of taking a creative approach" [4].

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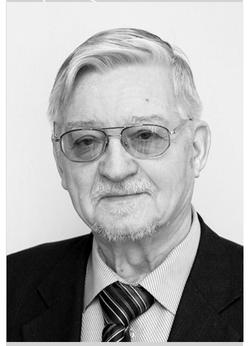

A.N. Rostovtsev

Management the Writing of Bachelor's Graduate Qualification Work in Construction Based on Technology of End-To-End Course Project

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Abstract

To resolve the issue of high-quality training of graduates in the field of Construction, in order to perform complex engineering activities, it is required to adopt new educational technologies and organizational forms of training. This article presents the implementation model of Bachelor's Graduate Qualification Work in Construction, as per IDEF0 methodology. The model is based on the technology of end-to-end course project work. The article demonstrates positive results of the model implementation in the learning process.

Key words: interdisciplinary integration, multidisciplinary integration, end-to-end course project technology, implementation model of Graduate Qualification Work, Bachelors of "Civil Engineering".

Introduction

The enthusiasm for future profession, motivation, systemic thinking, preparedness for solving inter- and multidisciplinary problems belong to the fundamental features of modern graduates of technical universities.

It is equally important for bachelors of "Civil Engineering". For example, the preparation for cross-sectoral activities in urban development, which cover creative research work and technical practice at all stages of production cycle of construction projects and urban areas, is the feature of the "Urban Construction" (UC) specialization. The production cycle involves design, construction, refurbishment and technical operation. Moreover, each of these stages considers the whole range of issues. In particular, the design involves simultaneous solution of urban planning, functional, structural, architectural and artistic, engineering and economic issues.

Therefore, it is required to prepare UC graduates who will be capable of resolving complex engineering activities, which cover the ability to *Plan, Design, Produce and Apply* engineering products and processes in the contemporary environment. It implies that students must be trained in accordance with the "4P" model, which is the basis for the Global initiative on reforming the basic (bachelor) technical higher education, CDIO Standard, to bring the content and the effectiveness of engineering education programmes in line with the development level of contemporary technologies and expectations of employers [1; 2, p. 48].

In our opinion, to resolve the issues of quality training of bachelors within provided time frame including the execution of Graduate Qualification Work, projecting the content of educational programmes is not enough. To improve efficiency, it is required to develop a detailed system of educational process management, specifically, "through the lens of super-discipline activities for mastering competencies" [3, p. 64]. We need a transition to new educational technologies and organizational forms of training.

Method

The development of General Cultural Competencies (GCCs), General Professional Competencies (GPCs) and Professional Competencies (PCs) required by the Federal State Educational Standards (FSES) is achieved by means of the competency-based approach, which is primarily characterized by interdisciplinarity. However, the effective achievement of the competency approach in education requires a clear understanding of "who regulates the process of mastering competencies and the gradual formation of competency, who and when records the achieved levels", "where and which competencies are formed in the learning process and what criteria prove that competencies have been mastered" [3, p.65].

For this purpose, our Department developed an integrated curriculum, which provides a distinct relationship between the content and the results of training in individual disciplines. Using the *technology of end-to-end course project*[1] this curriculum makes it possible to implement the multidisciplinary integration and "super-discipline" activities of students. The technology of the end-to-end course project includes a unit of disciplines integrated in accordance with the structure of material and information results of training. Through comprehensive and multidimensional consideration of the project object, the end-to-end course project makes it possible to develop course projects and term papers, which are closest to the practical engineering activity.

Also, thanks to interconnection of the project material, the end-to-end course project conduces to the productive, high-quality and timely work of students on their course projects and term papers. The end-to-end course project work is the basis, which assi8sts students in solving a more challenging task, i.e. the accomplishment of the Graduate Qualification Work in the short available time and at the adequate level.

Development of the process model

Along with support and management processes, the university educational process has a complex multi-level structure. This article considers one part of educational training of bachelors in a specific field. The article uses the example of its final training stage, which is preparation for the State Final Examination and its passing.

We developed ***the model of preparation for the State Final Examination and its passing*** (fig. 1, 2, 3), to demonstrate how to improve the development level of bachelor's competencies during preparation for the State Final Examination and also to reveal the relationships between all stages of the multidisciplinary process of implementation and defense of the Graduate Qualification Work.

This model was developed in accordance with IDEF0[2] methodology, which is also convenient for description of integration processes in education. The sequence, schematics symbols and arrangement rules of the process description in IDEF0 format were adopted in accordance with [4] as per governing documents[3].

[1] *The end-to-end course project work is understood as the parallel and/or sequential implementation of course projects / term papers in associated disciplines on the example of the same object. In earlier publications, we considered the technology of end-to-end course project work in detail.*

[2] *IDEF0-2000 (ICAM (Integrated Computer Aided Manufacturing Definition) is the methodology used to develop the functional model, which reflects the structure, the system functions and their binding information and material flows.*

[3] *Governing Documents - IDEF0 Methodology of Functional Modeling: Directive Document. - Moscow: Gosstandart of Russia, 2000. - 75 p.*
P 50.1.028-2001 Guidelines for Standardization. Information Technology to Support Product Life Cycle. Methodology of Functional Modeling. - Moscow: Gosstandart of Russia, 2001. - 54 p.

The behavior models presented in the rectangles are used to describe functions (work activities) performed by participants (by certain means). Participants include students, Graduate Qualifications Work supervisors, consultants and other individuals (arrows below). Left-hand-side- and right-hand-side arrows mean inputs and outputs of functions. Arrows on top mean management (managing actions, instructions, etc.). In order to obtain the description of actions sequence for successful implementation of tasks by students, each subsequent figure represents a stagewise breakdown (decomposition) of processes to the level of simpler sub-processes.

Fig. 2 demonstrates actions, material and information resources needed to commence Graduate Qualifications Work, and also the relationship between actions after

Fig. 1. Model of Preparation and Passing the State Final Examination (Contextual Diagram A0):

Competencies to be formed *– general cultural, general professional and professional competencies to be formed during educational process.*

Competencies of Supporting Disciplines (SDCs) *– competencies to be formed in the study of supporting disciplines.*

Materials of Supporting Disciplines (SDMs) *– graphic and text materials executed by students in the study of supporting disciplines and used at the State Final Examination.*

The formed competences of Bachelor of "Urban Construction" *– competencies mastered as per requirements of the Federal State Educational Standard, "Civil Engineering" training programme in compliance with "Urban Construction" specialization.*

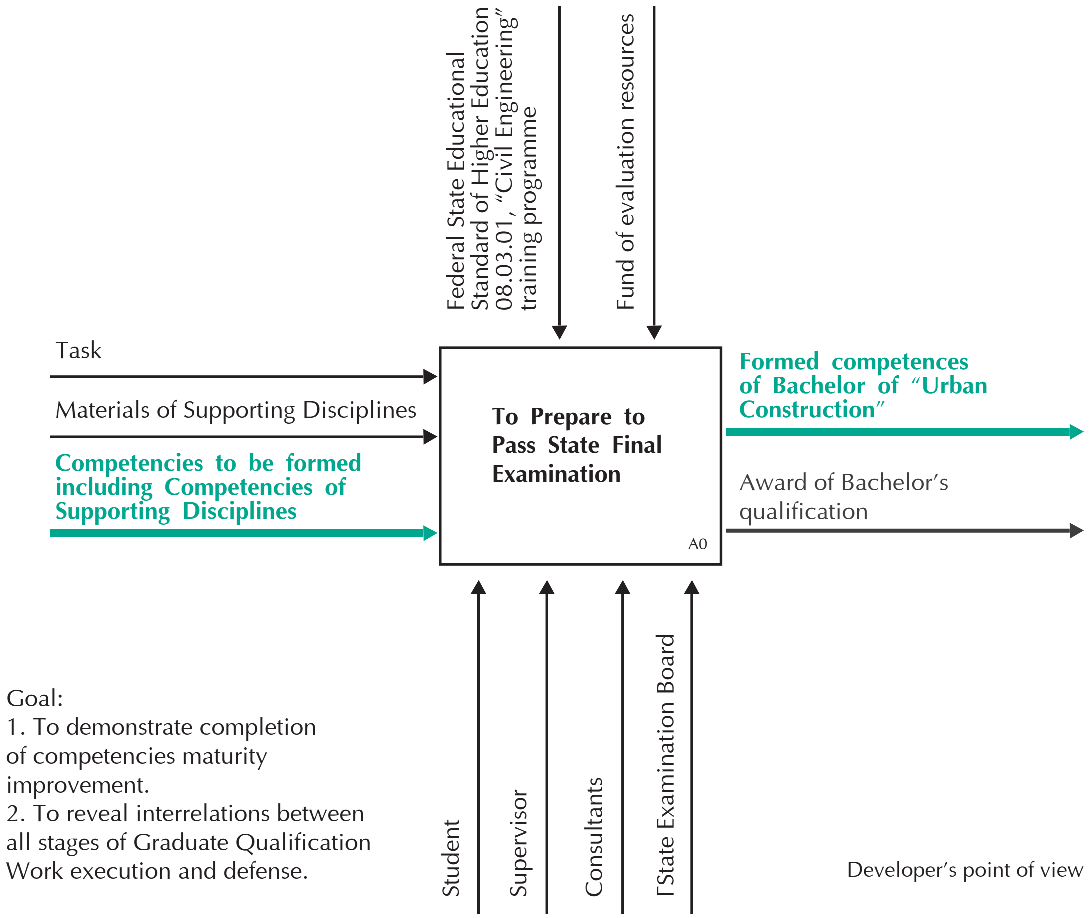


Fig. 2. Model of Preparation and Passing the State Final Examination (Decomposition of Contextual Diagram A0)

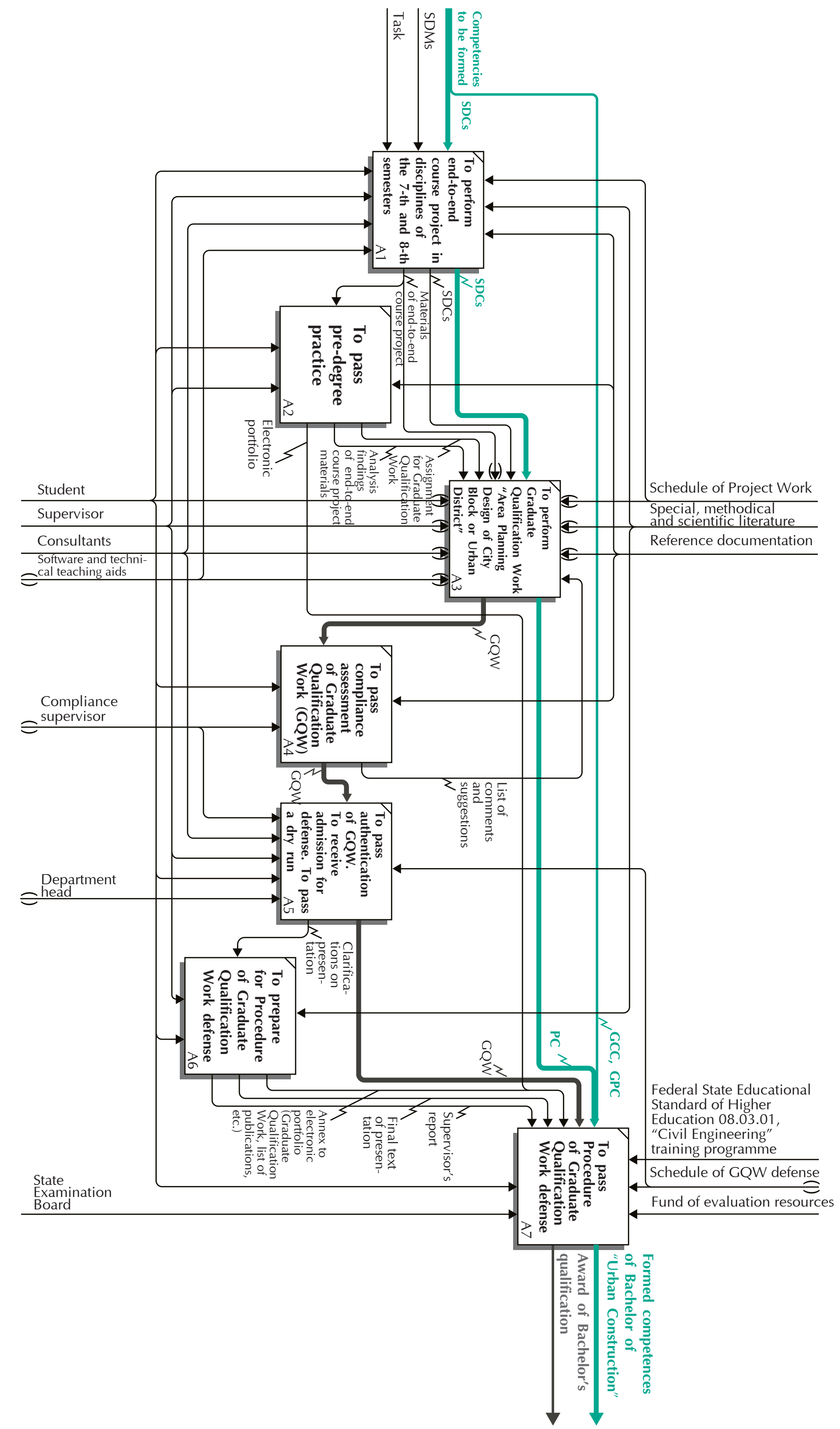
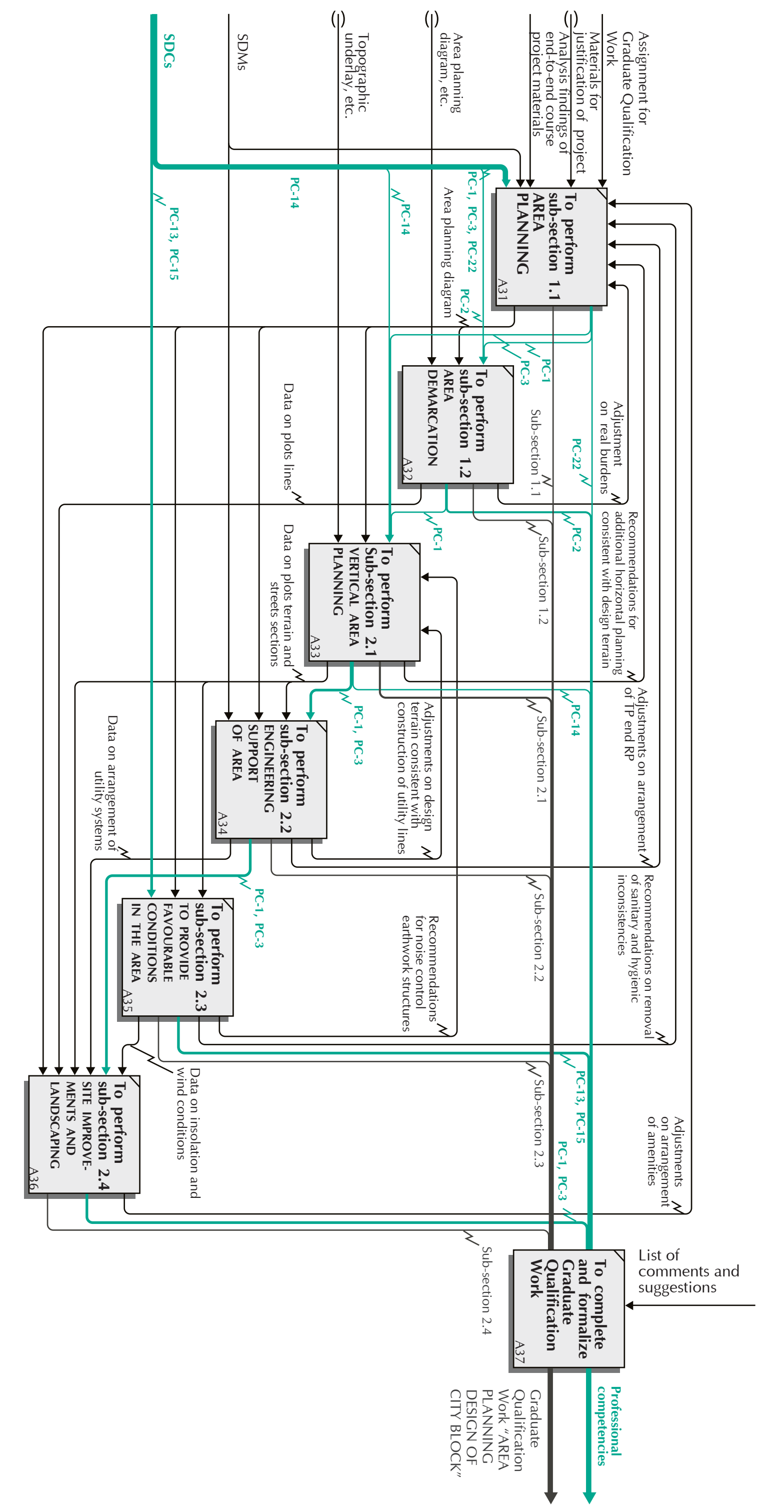


Fig. 3. Model of the State Final Examination Execution (Decomposition of Block A3)



Note – "Managing Actions" and "Participants and Means" in Unit A3, presented in Fig. 2 and related to each "Function" of the process, are not shown symbolically

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implementation of Graduate Qualifications Work required for passing the State Final Examination. Furthermore, Unit A1, "To Perform End-to-End Course Project ..." and Unit A3, "To Execute Graduate Qualification Work ..." have a similar scope, but different goals. Thus, course project solves teaching objectives, and its goal is the formation of a broad range of competencies, that is to learn to use as many methods, techniques and modes of solving engineering problems, etc. as possible. The goal of Graduate Qualifications Work, as the final training stage is to confirm graduates' professionalism, impart completeness to the results of End-to-End Course Project Work and submit them in the form of urban planning documentation package. This would prove competencies maturity of bachelors of urban construction. Graduate Qualifications Work is expected to resolve the issue of transition to a higher professional level.

At the initial stage of end-to-end course project, students work in a team, afterwards they work individually. As the object, students choose a real development area in accordance with the General Plan of the city district. They offer alternatives for area segmentation and perform term projects that contain data on justification of the area planning design. Students have to solve multi-criteria problems of choosing the best alternatives and accommodate requirements of different disciplines including those, which are not assigned by the task, but have arisen or have been specified during end-to-end course project work.

Fig. 3 presents the implementation process of this multi-faceted and iterative task. Generally, the function "To Execute Graduate Qualification Work ..." includes the following:

Tasks:

- to improve the level of mastering professional competencies;
- qualitative and timely implementation of Graduate Qualification.

Input:

- competencies acquired in the study of supporting disciplines (levels of mastering competencies);
- assignment for Graduate Qualification Work;
- materials for justification of the project;
- analysis findings of end-to-end course project materials;
- graphic and text materials accomplished during the study of supporting disciplines;
- basic data for sub-sections of Graduate Qualification Work.

Management:

- project schedule;
- reference documentation;
- special, methodical and scientific literature;
- list of comments and suggestions from compliance supervisors.

Mechanisms (participants and means):

- students;
- Graduate Qualification Work supervisors;
- compliance supervisor.
- software and technical teaching aids.

Function definition:

The implementation of sub-sections that follow "Area Planning" gives rise to management feedback, which represents iteration. It means that the function output affects the future implementation of other functions. Subsequently, it affects the original function with a significant large dominance. If required, following the results of the next sub-section, previous sub-sections are adjusted. The completion of Graduate Qualification Work is followed by compliance assessment.

Output:

- developed professional competencies (competency development levels);
- final version of Graduate Qualification Work.

Results

The experimental verification of the developed model in educational process was performed for two years and covered Graduate Qualification Works from 2015 to 2016.

The State Examination Board evaluated clusters of competencies that combined those of the Federal State Educational

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Standard in "Civil Engineering" Degree Programme, code 08.03.01. They included:

- ***Cognitive competence cluster.*** It reflected the availability and structuring of required professional knowledge, responsiveness to contextual and adequate updating (Professional Competence 1 and Professional Competence 13).
- ***Regulatory competence cluster.*** It demonstrated the ability to use a range of available knowledge to solve professional tasks, the use of methods and technologies of professional activity (Professional Competence 2, Professional Competence 3, Professional Competence 15, Professional Competence 21 and Professional Competence 22).
- ***Professionally valuable competence cluster.*** It revealed capacity for self-organization, pursuit of self-education and motivation to perform professional activities (Non-Technical Competence 2 and Non-Technical Competence 7).
- ***IT-cluster.*** In this case, it reflected the degree of software knowledge and computer technologies in Civil Engineering and also knowledge of data work methods (General Professional Competence 4, General Professional Competence 6, Professional Competence 2 and Professional Competence 14).
- ***Communicative cluster.*** It demonstrated students' skills of public discussion and their ability to defend their project solutions (Non-Technical Competence 5 and Non-Technical Competence 7).
- ***Contextual cluster.*** It characterized the quality of project documentation and its compliance with the task, standards, specifications and other reference documents (Professional Competence 3, Professional Competence 15).

Fig. 4 presents the State Examination Board's assessments of competencies level of graduates during the State Final Examination in 2015 and 2016. The assessments were based on "low", "medium", "sufficient" and "high" grading levels. We may note positive results of the model implementation both among motivated students and those with a lower initial motivation. Among the 2015 graduate students, the latter group prevailed. These were objective data obtained with the Dean's office and based on our observations. Besides, the data agreed with those of our colleagues – authors [5]. In the course of Graduate Qualification Work based on the end-to-end course project, students significantly enhanced their motivation to studies and their sense of responsibility. In order to ensure consistency between all sections of the project, students were eager to find the most efficient solutions. In the course of work, students updated their knowledge, translated their previous experience in course project work and transformed the newly obtained data. In other words, the "inter- and multi-disciplinary approach to education taught students to obtain knowledge from different scientific fields without guidance, to group and accumulate it in the context of tasks to be solved" [2, p 52].

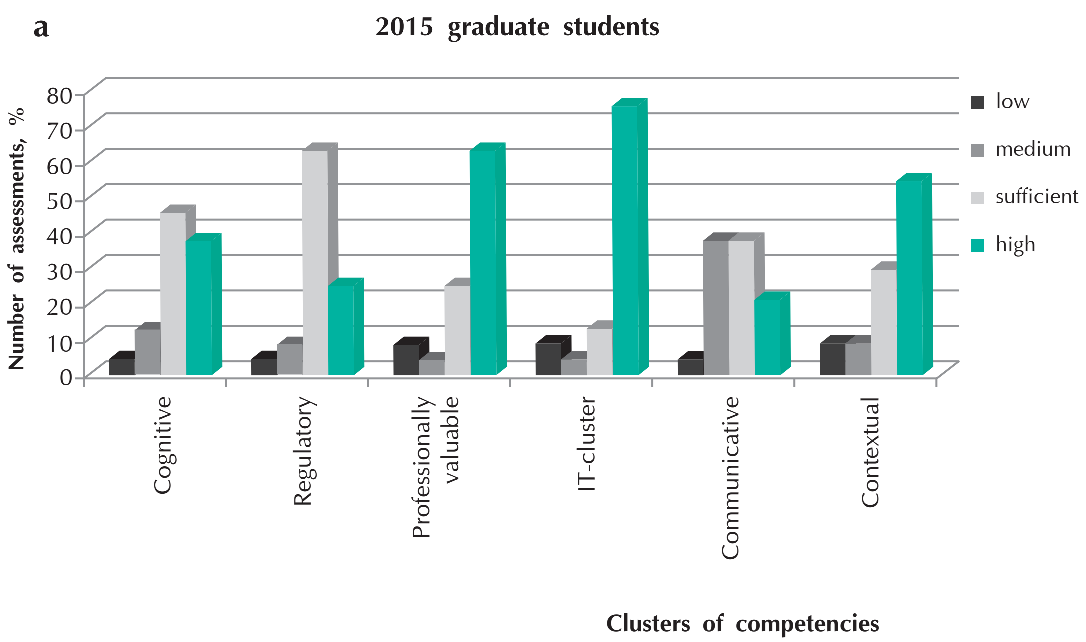
Summary

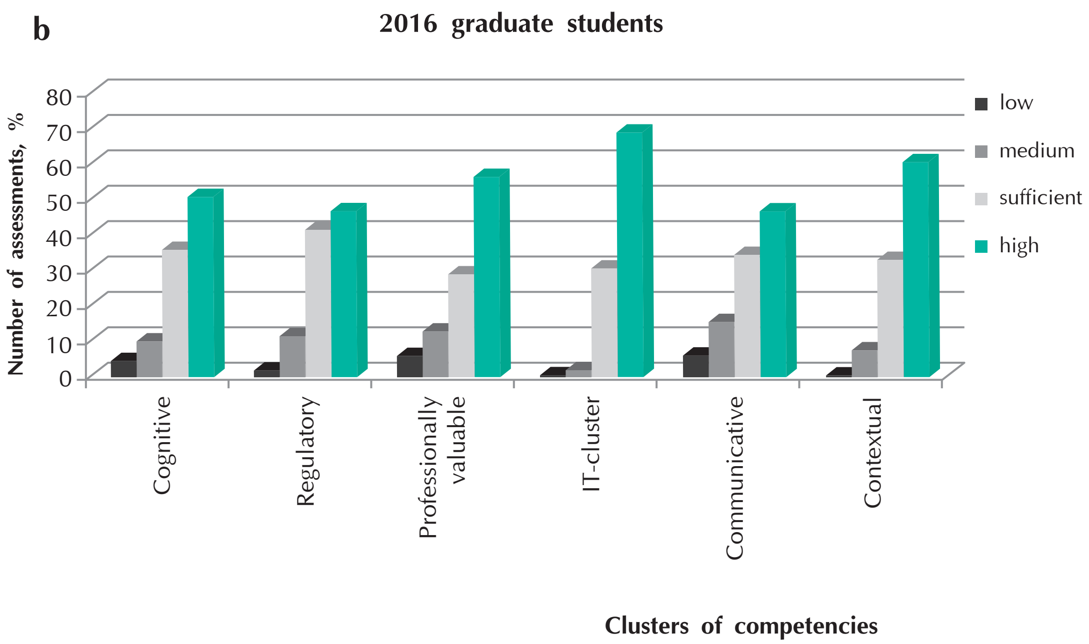
Thus, during passing the State Final Examination, we recommend to manage the process of Graduate Qualification Work through the end-to-end course project technology, which makes it possible to consider initial levels of competencies, trace their transformations in the course of performing the chain of sequentially and cyclically connected functions. This provides "feedback" in order to achieve the planned levels of mastering competencies, and estimate *the results achieved by students.*

This approach to bachelors' training allows to:

- significantly ***increase the level of competencies*** at any initial stage of students' motivation, due to multi-criteria objectives setting and solution of engineering tasks and a stepwise assessment of results;

Fig. 4. Assessment of Professional Competencies Levels by Bachelors During the State Final Examination





- through the use of interdisciplinary and multidisciplinary approaches, ***to develop the ability to "set a task" and interpret the results obtained***;
- ***develop skills in methods of system engineering***, other than simply include elements of real engineering activity in the teaching and learning process. It also means the creation of professional context as an integral model of future professional activity, including teamwork;
- significantly enhance ***the motivation and performance of students and teachers***, thanks to the focus on results and taking into account deadlines. It means the execution of Graduate Qualification Work at a high professional level within short deadlines and under existing conditions.

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Foreign Language Teaching Within "Aircraft Engineering" Programme

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Abstract

The article discusses the issue of enhancing the quality of foreign language teaching at engineering university. Within the education programme "Aircraft Engineering", this issue is of particular importance due to the current situation in this economy sector. The article examines the problems of foreign language teaching, describes and postulates the language teaching system developed at Samara University.

Key words: ESP, integrated course, project-based teaching approach, content-based instruction, competency-based approach, teaching principles.

The issues related to quality enhancement of foreign language teaching at engineering universities have retained their relevance and received close attention of faculty members and scholars over the years. It happens because, despite enormous efforts being made, the learning outcomes of education programmes and graduates' knowledge do not completely satisfy the requirements of modern labor market, the level of international cooperation and up-to-date technologies and equipment. The issues of ensuring foreign language teaching quality at engineering universities, when there is a decline in the instructional time and increase in students' independent work, are of particular importance. In addition, alongside education programmes such as "Computer and Information Sciences", "Information Security", etc. where the significance of foreign language (especially English) knowledge does not leave doubts in anybody, there are a number of programmes that train students for so-called closed industries. It means that employees who work within these industries are not free to travel abroad. This fact actually reduces students' motivation to learn foreign languages as travelling abroad is one of the most obvious motifs for them to study a foreign language. This trend is particularly pronounced in the education programmes related to aviation and rocket and space equipment. Low students' motivation impedes enhancement of foreign language teaching quality and requires immediate attention form faculty members.

Let us examine the peculiarities of foreign language teaching within the education programme "Aircraft Engineering" 24.03.04. When formulating learning outcomes of the foreign language course, the Federal State Education Standards of Higher Education and employers' requirements were considered. This analysis revealed a serious contradiction. On the one hand, the share of aircrafts produced abroad is significantly higher than that of domestic ones. It means that it is required to read technical papers in the original and, if necessary, to communicate with foreign partners. Therefore, knowledge of foreign language is rather important for students enrolled in this education programme, and the requirements for the level of foreign language knowledge are very stringent. On the other hand, according to the Federal State Education Standard approved on 21 March, 2016, a student "should demonstrate the knowledge of one of foreign languages at the level that is not lower than conversational one" (cross-cultural competency-10). The required level itself is not specified and is not compared with the Common European Framework of Reference for Languages. At the same time, universities have the right to define the amount of instructional time, the course content and curriculum at their discretion [1].

To resolve this contradiction, the goal and learning outcomes of a foreign language course delivered within the "Aircraft Engineering" programme were defined. In addition, a peculiar teaching system that includes the content, teaching formats and techniques was developed.

The goal of foreign language education is to develop the ability to and readiness for international communication, which secures communication-oriented language teaching. To attain this goal, the following purposes should be achieved:

1) to develop the ability to correlate language means with the certain communication purposes and situations;

2) to familiarize students with basic communication types;

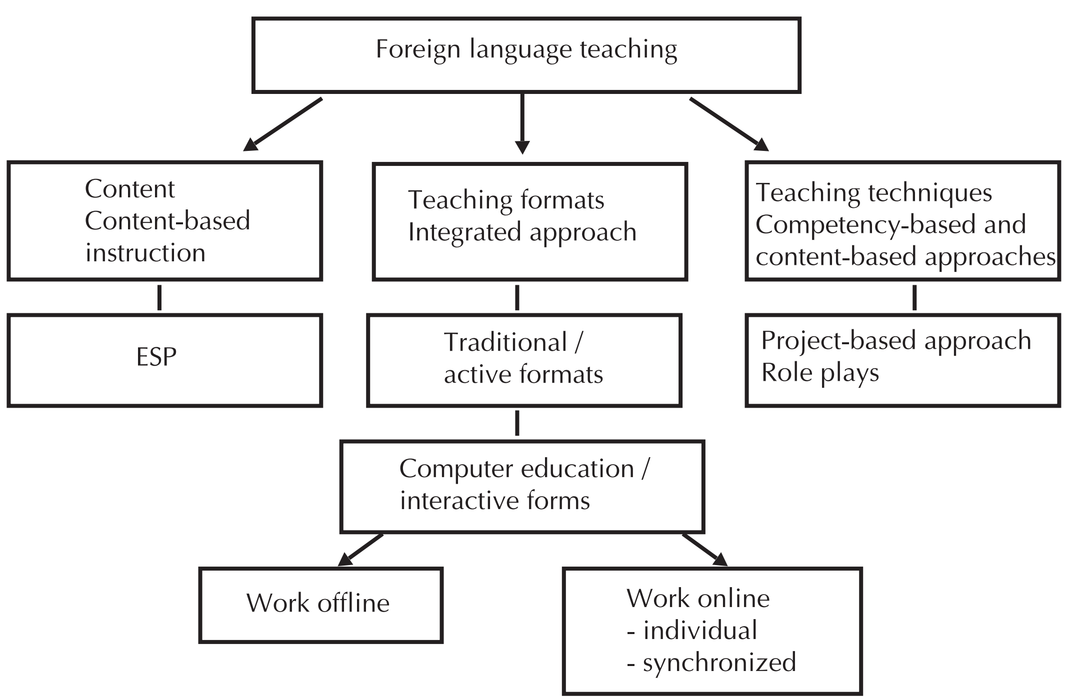
3) to secure intellectual development of a student, familiarize him/her with cognitive tools that ensure cognitive activity and capability of social interaction.

To address these purposes, a peculiar system of foreign language teaching was developed (fig. 1).

It is worth noting that Samara University offers the bachelor's degree programme in "Aircraft Engineering" that incorporates the course "Introduction to Foreign Language for Specific Purposes" which focuses students on learning foreign language for specific purposes. When developing the content of the course "Introduction to Foreign Language for Specific Purposes", the Departments of Foreign Languages and Russian as a Foreign Language primarily used the content-based approach. According to this approach, the language being learned is taught within the context of future specialty, which facilitates students' communication in the international professional community.

Learning ESP suggests good command of General English which is a purpose of

Fig. 1. Foreign language teaching within the course "Introduction to Foreign Language for Specific Purposes"



school curriculum in foreign language. At the beginning of the course, students' knowledge of foreign language is tested. The research conducted over several years has shown a low level of first-year students' proficiency in foreign language (55% of level A1, 35% of level A2, 10% of level B1 and higher). It results in the need to correct and review the language competencies that are developed within the first term when learning general topics related to engineering education (for example, "My University", "S.P. Korolev" etc.), which provides the students' readiness for learning ESP.

ESP is characterized by terminology, prevalence of scientific style, specific grammar, hence, there are such topics as "Aircraft construction", "Aviation origin", "Planes of the future" etc. for which the texts are taken from the original sources, teachers develop exercises to develop and master the skills of using grammatical structures typical for engineering literature as well as various language and speech abilities. It is worth noting that there is a lack of textbooks intended for learning ESP, therefore, teachers have to design and update the manuals, develop electronic courses and modules.

When selecting the types and forms of work, we rely on integrated approach that allows us to combine profession-based content with the study of system and rules of foreign language, to make foreign language a purpose and means of fostering professional knowledge as well as unite the potentials and advantages of traditional teaching forms and new technologies in learning process [2]. It allows for solution of the most urgent problems in teaching foreign language at engineering university, namely, absence of a single initial level of students' language knowledge, students' focus on learning engineering subjects, lack of instructional time assigned in curriculum. Using distant courses to arrange independent work permits filling-in the possible gaps in language knowledge, gaining additional information and skills necessary for mastering the major course, which, in its turn, leads to reduction of instructional time necessary for developing communicative skills.

According to the curricula, the share of independent work twice increases the share of classroom hours. Therefore, there is a demand for effective independent work and redistribution of students' learning efforts. Classroom hours are devoted to development and mastering communicative skills, first of all, speaking (monologue and dialogue) as well as listening as the most complicated form of communicative activity for students of non-linguistic specialities.

Drilling grammar, developing reading and writing skills are performed as independent activity, students do certain tasks to master grammar system (familiarization with grammar of the studied language assigned by the school curriculum) and read texts and fulfill the exercises to prepare them for classes.

When designing integrated foreign language course, the increased requirements for independent work based on computer are to be taken into account. The course is to include the tasks done online and offline.

Offline activity is aimed at mastering language skills and includes doing tasks by means of special software (for example, lexical driller), video- and audio-aids with subsequent discussion in the classroom or online. The online work is subdivided into individual (search for information, sending e-mail messages, blog posts, online-tests etc.) and synchronized, interactive (student – student, students – teacher) activities in chats and videoconferences. This structure enables development of communicative skills, students' motivation for learning foreign language using principles of adequate learning load, reasonable distribution of learning efforts, joint activity and interpersonal interaction in academic process.

In choice of teaching methods, we rely on competence- and content-based approaches. The competence-based approach provides students' development of competences assigned by HE FSES, namely, apart from the mentioned above CC-10, ability to possess thinking culture, perceive and analyze information, set goals and select the ways of their achievements (CC-1), ability to logically build oral and written speech (CC-2) [1]. These competencies reflect three main situations of using language identified in psychology, namely, as a tool of social perception, individual perception, personal socialization [3], attracting students' attention to cognitive and communicative language functions. When learning foreign language, these functions are given close attention as language is both object of study and means of perceiving and communication. Cognitive function provides formation of linguistic world view, influences the intellectual sphere of a speaker's personality [4], which is necessary for development of new technology in the condition of high-tech production and global ecological problems. Communicative competence formation is the goal of teaching foreign language at any level in any course of foreign language. Nowadays, ability to effectively communicate is one of the requirements for engineers, which is imposed in different countries [5, 6]. Thus, according to www.career.ru site, Russian employers distinguish among the principle qualities of a young specialist along with initiative, result-orientedness, high responsibility, as well as sufficient level of communicative competence, correct oral and written speech and presentation skills.

The content-based approach is aimed at applying the teaching methods, relevant for future professional activity, particularly for design-and-engineering (aggregation, analysis and systematization of background information), experimental and research (survey description, report on the task fulfilled), organizational and management (organization of small groups work) [1]. The project-based approach, role plays and business games are the most efficient in terms of competency-based and content-based approaches. The project-based approach draws attention of teachers of different courses in technical universities as the project work supposes determination of the existing problems and development the ways of their solving. Methodological literature describes in detail the application of the project-based approach at English language classes, different project types are singled out and their peculiarities and differences are indicated [7]. It should be emphasized that a project is implemented in several stages. The project requires a large amount of individual work on implementing the purposes along with the classroom team work when the students guided by the teacher analyze the problem and determine the stages of its solution. The work results are presented in a classroom as well that encourages the formation of public speaking skills, audience interaction, expression of interest and personal opinion, the integral part of communicative competence. The project work at foreign language classes requires different tests, and sometimes surveys and questionnaires – in this way the communicative skills and passive and active skills in working with different types of texts, information analysis are formed. The project-based approach allows implementing the principle of accounting the educational subject labor intensity and optimal planning of individual work, rational distribution of work content over the types, as the project efforts exceed considerably the volume of work in determining the problem and presenting the results and the individual work according to the curriculum, as it was mentioned above, exceeds significantly the classroom hours.

The content-based approach determines the combination of the project-based approach with role plays and business games when teaching foreign language at "Aircraft Engineering" education programme. In common projects the students develop the problem topics on their own, in games they act certain parts simulating quasiprofessional activity. For example, "At the design department" game project shows the structure and specific nature of aircraft design departments. Then the students work on the project (for example, development and presentation of cost-efficient aircrafts for low population regions) according the parts. In this way the principle of sequential simulation of content, form and conditions of professional activities in students' learning is implemented.

It is worth noting that development of relevant technical and scientific issues in the course "Introduction to Foreign Language for Specific Purposes" provides the continuity of educational levels, as the students get acquainted with the methods of science activity which is the main one in master's degree programme. The project-based work increases students' learning motivation. The students who have achieved the best results at game conferences have the opportunity to speak at university, inter-university, Russian and International conferences. Such speeches not only increase inner motivation, give self-satisfaction but also can result in scholarships increase that is the significant factor of external motivation – the principle of a student personal involvement into learning activity is achieved.

Thus, the course "Introduction to Foreign Language for Specific Purposes" is aimed at learning goal achievement and address the outcomes related to the goal. Subject nomenclature, being the education content, encourages formation of communicative skills within professional context and the ability to correlate language means with certain goals. The integrated course with efficient distribution of students' efforts in classroom and individual work allows mastering the required language skills, covering possible gaps in starting language proficiency, focusing on the most challenging communication aspects. Use of the project-based approach, role plays and business games encourages implementation of the content-based approach principles, organization of quasiprofessional activity at the English language classes, formation of cognitive skills and ability to interpersonal communication. The system developed ensures education motivation, continuity of professional training stages and encourages the increase in quality of language training at the "Aircraft Engineering" education programme.

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Students' Graphical Culture Development in the University Virtual Learning Space

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Abstract

The article analyzes the problems related to the development of students' graphical culture in modern virtual environment of an engineering university. Graphical culture is defined as a matureness of productive professional competencies shaped within the virtual learning space of a university. They include broad-based graphical knowledge and graphic design thesaurus.

Key words: virtual learning space of engineering university, students' graphical culture, virtual reality, social reality.

New social virtual environment stipulated by the development of communication technologies has significantly changed the present society and engineering education. The educational environment of engineering university is becoming more and more virtual. This fact is of particular urgency in the case of continuous growth of the Internet user number and its expansion and impact on education. Initially, "cyberspace" was regarded as a virtual environment [1, p .3]. Development of computational engineering furthered the spread of this term. Processes and phenomena specific to the computer networks were termed as virtual environment in contrast to the real one. As noted by T.A. Rubantsova and N.V. Koltunova, "Being a part of a real world, social reality demonstrates the features of the objective reality, therefore, its learning should be based not on our sensitive perceptions and illusions, but on understanding of its characteristics peculiar to the reality itself which exist beyond human consciousness" [2, p.106]. Being a part of a virtual environment, simulacra, however, created by computers allow designing ideal objects that resemble real ones.

Virtual environment, although reflexive, is social as it is modeled by the educational actors. The virtual environment makes it possible to model various objects of social reality, for example, buildings, units of technical infrastructure, etc. However, it is necessary to remember while enhancing the model of virtual environment, we actually simplify the copy of social reality. It is worth noting that a full convergence of virtual environment and reality is impossible. Thus, new types of reality occur within the social reality. They are of virtual character and created within the Internet that serves as a technological basis. One of the essential spheres of virtual environment is educational environment of a university, which has recently become an important component of higher education in the Russian Federation.

In modern engineering university, a new pedagogical environment, i.e. virtual learning space, is currently being developed. It is operated on the basis of up-to-date computer technological and the Internet. Today, professional activity of an engineer, as well as high technologies implemented into manufacturing process, is becoming more and more complicated. Therefore, there is a need to rapidly acquire knowledge in a short time period. It concerns both educators and students. Despite a great number of studies devoted to virtual environment issues, the notion of "virtual environment" is ambiguous and disputable. The pedagogical literature often defines the term "educational environment" through the prism of analysis and description of technical tools which help create new learning space. S.R. Tumkovsky, G.P. Putilova, and L.N. Kechieva believe that a set of computer tools and the way they are applied form the information and education environment [3, p. 22]. Definitely, this aspect of analysis is essential for the study of virtual learning space, however, it is worth noting that virtual learning space and virtual educational environment are different notions. The former is focused on the analysis of methods and tools to provide technical support of the training process. The latter involves new methods and techniques used by an educator and students to master competencies required for the job.

One of the main tasks of modern education philosophy and pedagogy is the development of new modes and formats of education, i.e. virtual learning space of a university. Education is the process of search and mastering of certain set of knowledge, skills and competencies required for the job. The basic learning outcomes are formulated as a required level of graduates' theoretical and practical knowledge.

In this article, the term "virtual learning space" should be understood as a new pedagogical and technological educational environment which is based on the use of computers and telecommunication systems in engineering education.

Graphic design disciplines are considered a theoretical basis for special engineering education. They are an integral part of professional engineering training which is basically provided in the virtual learning space. As a result, the methodology of these disciplines is subject to increasingly severe requirements.

Being one of the actors of the training process, an educator defines the way graphical information is presented in the virtual learning space, which helps students independently model and visualize various things while mastering teaching materials. Graphics plays a key role in developing communication-information environment in engineering education. As noted by M.V. Samardak, "Being an integral component of engineering education, graphic design training should perform the following interconnected functions: educational, cross-technical, professional, and cross-cultural" [4, p. 363].

Due to educational and cross-cultural functions, a student develops himself or herself as a personality and starts applying one of the ways of conceiving the world – graphical one. As noted by M.V. Samardak, "cultural focus of graphic training is rooted in its role to preserve, generate and transmit spiritual values, mainly perceptions of graphic language as a synthetic language that has various systems of information presentation (graphical, symbolic), its inception, development and role among other languages of the world culture" [4, p.364]. Graphic activity plays a crucial role in shaping students' cognitive abilities in learning space of a university. While mastering graphic design disciplines, a student develops spatial thinking which is connected with the productive forms of human activity.

In cross-technical sphere, graphic design training encourages development of technical thinking by shaping spatial one. The road to polytechnic generalizations that reflect common regularities of the studied objects is paved by the intensive use of graphical conventions. The above-mentioned functions indirectly contribute to personality development and self-development, build the foundation for more enhanced self-identity and professional self-fulfillment.

Graphic design training of engineering students constitutes a basis for professional training of future engineers. Its specific features are due to the fact that it is mainly shaped in the virtual learning space created by an educator. Engineering languages of graphical presentation of information are referred to graphic-geometry disciplines which most fully use the functions of professional communicant. When specifying the elective component of graphic design disciplines, it is essential to consider the peculiar features of students' further professional activity. For example, within the professional activity of designers, the objects and the results of geometric modeling are regarded as a geometric system which corresponds to the stages of engineering activity in terms of form and structure: graphical model for cognitive activity and symbolic-graphical model for transforming activity.

Thus, target-oriented graphic design training delivered in the virtual learning space of a university provides a student with a set of knowledge and skills, peculiar attributes required for professional problem solving, i.e. professionalism. The quality of multifunctional graphic design training that meets the requirements for general education, professionalism and professional culture of an engineer, comprises the education potential of a personality which can be termed as a level of graphical culture.

Therefore, graphical culture can be defined as a matureness of productive professional competencies shaped within the virtual learning space of a university. They include broad-based graphical knowledge and graphic design thesaurus. As a result, a student demonstrates high performance which is rooted in the system of graphical skills and abilities. Mastering graphic design disciplines shapes a high level of spatial thinking that secures the processes of perception, structuring, and decoding of graphical professional information. Development of graphical culture in the virtual learning space of a university is a multifaceted and complicated process of graphical thinking shaping within the university virtual environment. It involves several stages: from the basic graphical knowledge to comprehensive and creative understanding the ways of implementing this knowledge in professional activity.

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Continuous Mastering of Computer Technologies as a Mandatory Condition for Highly Qualified Specialists' Education in the Sphere of Optical Engineering and Electrooptic Instrument Engineering

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Abstract

Specialists' training in the sphere of optical engineering and electrooptic instrument engineering can be divided into three stages from the standpoint of using information and computer technologies: 1. Study of general principles of information and computer technologies; 2. Mastering these technologies in design of typed blocks of optic and electrooptic systems; 3. Instruction in computer modelling based on systematic approach to designing electrooptic complexes as a whole.

Key words: computer technologies, optical and electro-optical systems instrumentation.

Today the role of information and computer technologies, in particular, computer modelling, is well known for specialists' training. They are paid much attention in implementing education programmes in the sphere of optical engineering and electrooptic instrument engineering including laser one. The complexity of modern electrooptic tools and devices consisting of various by nature blocks and units (optical, mechanical, electronic etc.) requires applying systematic approach at all stages of design, production, and research [1], which is now impossible without computer technologies.

The goal of this article is to introduce the readers to the experience of continuous study and application of computer technologies in training specialists in the sphere of optical engineering and electrooptic instrument engineering at the Faculty of Optical Information Systems and Technologies (FOIST), Moscow State University of Geodesy and Cartography (MIIGAiK).

Future specialists' training in optical engineering and electrooptic instrument engineering can be divided into three stages from the standpoint of using information and computer technologies: 1. Study of general principles of information, computer devices, and computer technologies; 2. Acquiring skills of using these technologies in computer modelling of typed blocks of optic and optoelectronic systems (radiators, optic systems, scanners, photodetectors, electronic blocks, etc.); 3. Instruction in computer modelling based on systematic approach to designing electrooptic complexes, i.e. considering it as a whole consisting of separate blocks described by submodels.

The first stage has been secured was realized in numerous curricula and education programmes for a long time. For instance, such courses as "Informatics", "Mathematical modelling", "Engineering and computer graphics" are taught. The curricula of these courses are regularly revised and updated improving their hard- and software.

The second stage was secured in teaching particular general professional disciplines, such as "Applied optics", "Sources and receivers of optical radiation", "Electronics and microprocessors", "Bases of designing precise instruments", "Calculation of optic system", "Lasers", "Technology of optic-electronic instrument engineering", "Design of optical instruments» etc. In this case, modern computer methods of synthesis, analysis, and optimization of typed blocks in optic and optic-electronic instruments and systems are used.

The significance of computer technologies should be particularly underlined taking into account that it is just a specialist in the sphere of optical engineering and optic-electronic instruments and complexes who is to be the first in optimizing sort of signals coming from a primary data processing system (PDPS) at the electronic block input.

Potentials of modern computer engineering stipulate high demands for parameters and characteristics of blocks and units which are the foundation of most contemporary measuring and tracking PDPS – optic systems, scanners, photo-detectors [1-3]. Lack of attention to PDPS optimization results in the situation, when design can only be performed at the circuit and schematic (structural and algorithmic) levels, but not at the parametric one. It means that academic process does not lead to mastering skills and abilities of selecting definite numerical values of parameters and characteristics of both the whole system and its separate units.

At FOIST (MIIGAiK) computer programs are used at this stage to monitor, test, and assess students' general professional competencies. Tests focus students' attention on the basic sections of discipline as well as some issues practically important to evaluate the quality indicators of particular units and blocks of standard optic and optic-electronic facilities. They also help identify the gaps in knowledge of definite course units.

At this stage the tests can be divided into two types – those for internal disciplinary and those for interdisciplinary monitoring (complex tests and control tasks). The function of the former is to check the knowledge of basic theory and develop skills of handling them within the course of particular discipline. In this case, knowledge of basic parameters and characteristics of one of the blocks in the whole system as well as their most significant magnitudes, formulas used for qualitative and quantitative description are monitored.

Interdisciplinary tests and tasks play a special role in future specialists' training. A student is to know both basic physical principles of their functioning and methods of their combination within one structure. He/she is to be able to describe particular situations and their computer models (submodels) of standard systems. In this case it is necessary to draw on experience of similar model developments, existing standards and manuals of element base.

At the third stage it is important to apply knowledge, skills, and abilities acquired at the second stage for mastering general methods of computer modelling of optic-electronic systems and complexes. This method allows solving a lot of problems of circuit and parametric analysis or synthesis often occurred, at least, at the first stages of designing different optic and optic-electronic devices and systems operating in complicated and rapidly changing conditions. The main stages of the analysis or synthesis as well as methods of appropriate computer modelling are described in [3].

Computer modelling applied in design, research, and tests of modern optic and optic-electronic devices and systems allows simulating various structures of necessary adequacy, calculating the values of performance indicators (quality indicators) in different background-target circumstances, evaluating the integrity and quality of existing element base, solving other problems, for example, development time reduction, its cost reduction. In some cases it significantly reduces the cost and durability of some expensive and time-consuming experiments.

It is of particular importance for designing complicated land, air, and space-based systems, for example, infrared systems [4,5] taught for senior students of FOIST in profile 12.05.01 "Electronic and optic-electronic special purpose instruments and systems". A wide application of computer modelling is typical for such courses as "Modelling of optic-electronic systems", "Computer modelling in optics", "Laser equipment and laser technology", "Orientation and navigation systems", "Optic-electronic tracking systems", "Lidars and scanners" and some others as well as programmes of design engineering, research, and production internship prior to graduation.

When studying these courses students are usually engaged in initial data formation, consideration of different options for the problem solution, selection of software and identification of conditions for its implementation, choice of common structure of a computer model and its submodels. The transfer functions (baseband transfer functions) of definite model blocks are often used as those submodels, for instance, unit "Structure of general model and algorithms used to work with it" which includes submodels "Operating scenario of optoelectronic systems", "Optic system", "Photodetectors", "Electronic assembly", "Display". The structure of the entire model can include database unit "Elements and algorithms of information processing", unit "Propagation medium of optical signal" as well as unit "System quality indicators" which consists of submodels "Signal-noise relationship at the output of optic-electronic system" or "Minimal permissible temperature difference". In [1-5] there are the examples of computer models and submodels used by senior students of FOIST (MIIGAiK) in their learning and research activity.

Conclusion

The experience of FOIST (MIIGAiK) has shown the feasibility of implementing computer methods and modelling at all stages of specialists' training in the sphere of optic engineering and electrooptic instrument engineering.

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Summary

COMPETENCY DEVELOPMENT AND INNOVATIVE TRENDS IN ENGINEERING E-LEARNING

A.V. Putilov, I.A. Baranova
National Research Nuclear University "MEPhI"

The article examines the main issues related to the innovation implementation into the engineering e-leaning. It presents the examples of using information technologies: micro-knowledge, animations, simulation, and chatbots.

MOTIVATIONAL TYPES OF PROFESSIONAL RETRAINING PROGRAMME ATTENDEES

S.M. Kazantseva
Tyumen State University

Demand for education is consistently high in Russian society. Apart from basic higher education, various retraining programmes account for a large share in service sector. The main goal of the retraining programme on Managerial Personnel Training for National Economy (the President programs) is to teach people having primarily engineering education how to manage a modern company. The article examines basic motivational types of retraining programme attendees. Knowledge of motivational types and ways of defining them are required for education programme design, however, this problem is currently neglected, which results in poor education quality.

POPULARITY OF ENGINEERING PROFESSIONS: RESULTS OF SOCIOLOGICAL SURVEY

I.A. Kaplunov, E.V. Klyushnikova
Tver State University

The article discloses an analysis of the current state of school students' interest in scientific and engineering majors – a comparative analysis of the popularity of engineering professions and university majors among youth based on the results of sociological surveys and informational and analytical materials of higher educational institutions efficiency monitoring.

THE BALANCED SCORECARD AS A TOOL TO DEVELOP BUSINESS EDUCATION AT LEADING UNIVERSITY

A.A. Kozlova, A.V. Putilov
National Research Nuclear University "MEPhI"

The article deals with the relevant issues concerning innovative development of education system. It describes the role of business education in development of innovative economy. The role of the Balanced scorecard in enhancing business education is defined. The Balanced scorecard performance indicators for a leading university are evaluated.

"YOUR FUTURE STARTS TODAY": FIRST-YEAR STUDENTS' INSIGHTS IN ENGINEERING PROFESSIONS

E.V. Kondrashova
National Research University "Higher School of Economics"

The article considers the connection of professions of the future with engineering, what first-year students think of their future engineering job and what demands are made by future engineers today to do their job successfully in future. The article reveals the future specialists' principle requirements as well as establishes the key factors of profession selection.

INTELLECTUAL GUIDELINES (REFERENCES) OF ENGINEERS IN RENOVATING MODERN PRODUCTION

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

Engineers lack sound guidelines to identify the level of changes in construc-tions and technologies. It leads to problems in planning and managing the renovation of modern production. The article discusses guidelines for gradu-al identification of level of changes in technologies and constructions based on interconversion of object and process systems.

PECULIARITIES OF ENGINEERING EDUCATION WITHIN THE INNOVATION-BASED ECONOMY

O.A. Moiseeva, Yu.P. Firstov, I.S. Timofeev
National Research Nuclear University "MEPhI"

In today's fast-changing market, the link between the decisions made in different fields is of significant importance. This peculiarity should be reflected in engineering education. The theory of technological modes serves as a methodological basis for the current research. It has been revealed that engineering-economic environment is shaped as a combination of technological modes, within which the problems of harmonized development of technologies are solved. The models to shape engineering knowledge under modern conditions are proposed.

DEVELOPMENT OF ENGINEERING CREATIVITY IN THE SYSTEM OF SPECIALISTS' TRAINING

M.K. Romanchenko
Novosibirsk Industrial-Power-Engineering College

The article discloses the issue of developing engineering creativity as an element of the qualified specialists' training. The researched forms and methods of organizing engineering creativity in Russia are analyzed in comparison with these activities in foreign countries. The author shares his experience in organization of classes aimed at development of creative abilities of students and provides the achieved results. The proposed conclusions underline an opportunity for transferring best practices to the practical activity of other educational institutions.

THE PROBLEM OF VALUE-BASED GUIDELINE FORMATION FOR FUTURE PROFESSIONAL ACTIVITY

T.A. Fugelova
Tyumen State University

Contemporary education is aimed at training engineers capable of transforming the environment.
Formation of value-based and responsible attitude of future engineers to the environment as a basis of accession into culture taking into account personal qualities and specific living conditions, involvement in innovative activity is a condition and prerequisite for their professional mobility.

IMPLEMENTING WORLDWIDE CDIO INITIATIVE AT SIBERIAN FEDERAL UNIVERSITY: HEAT POWER ENGINEERING PROGRAMME

E.A. Boiko, P.V. Shishmarev, D.I. Karabarin, A.A. Pikalova
Siberian Federal University

The paper describes the experience and results of implementing the Standards of the CDIO Initiative into the Bachelor's degree programme in heat power engineering provided by Siberian Federal University.

IMPLEMENTING CDIO INITIATIVE IN RUSSIAN UNIVERSITIES: INTERIM RESULTS AND PROSPECTS

R.A. Dolzhenko
Non-state Higher Educational Establishment "UMMC Technical University"

The paper describes interim results of implementing the CDIO initiative into education programmes of national universities. The author has indicated the trends in publishing academic papers on the topic. The factors hindering CDIO implementation into national education have been identified. The author gives recommendations and suggests the algorithm for implementing CDIO into the education programme of the Russian university.

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SUMMARY

ON THE INFLUENCE OF THE BOLOGNA PROCESS ON DEVELOPMENT OF HIGHER EDUCATION IN RUSSIA

I.N. Kim
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Among the educational community there is a common opinion of the negative impact of the Bologna process on the national higher education. In the context of FESTFU we can say that the transition to the two-tiered system of education has substantially changed educational and scientific activities of universities. Regulatory framework was developed for ensuring educational and research activities in the terms of the Bologna process. It includes updating teachers' activity, developing their educational and teaching culture, preparing them to effectively use the modern technologies in training and allowing them to bring educational process to a new level.

ENGINEERING EDUCATIONAL PRACTICES TO TRAIN FUTURE ENGINEERS IN THE USA

I.A. Monakhov
Tver State University

Based on the analysis of engineering educational practices in the USA as well as the governmental support of education programs, the article reveals strengths and weaknesses of stimulating the youth to choose engineering education and engineering professions.

IMPLEMENTATION FEATURES OF INTERDISCIPLINARY RELATIONSHIPS IN THE SYSTEM OF UNIVERSITY TRAINING OF SPECIALISTS IN THE FIELD OF MECHANICAL ENGINEERING, 15.04.01, AND THE ENHANCEMENT OF THE ROLE OF TECHNICAL SPECIALISTS IN CONTEMPORARY SOCIETY

I.N. Romanova, A.Yu. Krasnopevtsev
Togliatti State University

The paper considers major requirements for development of interdisciplinary relationships model during specialists training in Mechanical Engineering, in order to enhance their role in contemporary society.

WAYS OF IMPLEMENTING PROFESSIONAL SPECIALIST TRAINING FOR DEFENCE INDUSTRY COMPLEX

T.Yu. Dorokhova
Tambov State Technical University

The paper introduces the description of learning environment, which accumulates the resources of scientific, educational and production structures and allows ensuring the participation of students and master students in learning, scientific and research activities. Creation of practical-oriented environment within the integrated scientific, educational and production structures allows implementing the educational technologies for practical-oriented learning based on the activity approach and expanding the use of problem- and project-based learning for creating the innovative ideas.

DEVELOPING MANAGERIAL COMPETENCIES OF MASTER'S CIVIL ENGINEERING STUDENTS BY INTODUCING MODERN TEACHING TECHNIQUES

M.S. Gusarova
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The article proposes the design of a unique course "Design HR engineering" for master's civil engineering students, which is aimed at shaping managerial competencies. The course is intended to develop managerial competencies by means of active teaching techniques: business games, project teams, case-studies, workshops. These teaching techniques contribute to developing leadership skills within the formats that are familiar to future engineers (engineering and project-based approach).

SIMULATION IN PROFESSIONAL EDUCATION

O.V. Yezhova
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The article is devoted to the issues of simulation as means of research in professional education. A classification of pedagogical models is developed according to their most essential features: application area, form, structure, subject of research, development in time, level of reflection of system's core features, level of specification, problem broadness. A brief explication is provided for each class of models. Definitions of the terms "model of a specialist" and "model of specialist's training" are proposed.

PROJECT-BASED LEARNING AND RESEARCH AT UNIVERSITY

S.S. Kugaevskiy
Ural Federal University

The article analyzes the changes in practice-oriented training of stu-dents. It describes the example of making arrangements for enhancing stu-dents' motivation to conduct research and development activities while im-plementing the project within the framework of the Resolution No. 218 of the Government of the Russian Federation.

ANALYSIS OF FSES TEXTS OF THE LAST GENERATIONS OF ENGINEERING PROFILES (SPECIALITY "NUCLEAR PHYSICS AND TECHNOLOGIES", BACHELOR DEGREE) IN FOREIGN LANGUAGE SUBJECT

S.I. Prokopieva
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The article analyzes the Federal State Educational Standards (FSES) of the latest generation by the example of speciality "Nuclear Physics and Technologies", Bachelor degree programme, Foreign language course. The principle changes in the components of the FSES 3 and FSES 3+ standards are considered in the higher education system.

PEDAGOGICAL CONDITIONS FOR RESEARCH-TECHNICAL CREATIVE ACTIVITY IN TECHNOLOGY TRAINING

M.K. Romanchenko
Novosibirsk Industrial-Power-Engineering College

The article is concerned with the study in the issue of development teachers' creative potentials engaged in students' technology training.
Having analyzed the practice of research-technical creative work, the author shows the dynamics of students' achievements from the fifth to the eleventh form, observes the changes in general awareness of process technology and understanding the essence of these processes and their perspective improvement.
The work defines pedagogical conditions for research-technical creative activity in technology training consisting in the idea of students' special attitude towards labour, development of profile skills and features, such as: civil liability, patriotism, and need for labour activity. The principle aim of this development is to involve students in labour activity based on their in-born individual abilities, to teach them to apply modern scientific achievements.
Studying the dynamics of transforming a student's cognitive interest and the results of research in the sphere of pedagogy, the author justifies a number of concepts stated in the article to provide efficient technology training.

EXPERIENCE IN DESIGN AND IMPLEMENTATION OF EDUCATIONAL SOFTWARE WITHIN STRENGTH OF MATERIALS AND STRUCTURAL MECHANICS DISCIPLINES, TSUAB

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F.A. Krasina
Tomsk State University of Control System and Radioelectronics

The article presents the results of software implementation into education process provided by the department of "Structural Mechanics", TSUAB. These software packages are intended to solve problems in the disciplines "Strength of Materials" and "Structural mechanics". They allow checking the correctness of manual calculations, rapidly finding and eliminating the mis-takes being made, avoiding a great number of typical calculations. The de-veloped software packages are characterized by advanced interface; the ini-tial data are presented in a way that is familiar for students; the software packages are free.

ENGLISH FOR SPECIFIC PURPOSE FOR FUTURE ENGINEERS: SOFTWARE APPLICATION

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I.A. Malinina
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The paper studies pedagogical reasons to apply training software and suggests software technology for learning ESP in technical higher schools. The main part of the article is devoted to the particularities of multimedia training course introduced at the first stage of foreign language training, as well as software to test students' ESP skills during further training.

STUDENTS' TRAINING IN DOING LABORATORY WORKS ON PHYSICS

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Based on the analysis of advantages and disadvantages of laboratory training methods on physics, personal practical experience, the article describes and justifies intensification of students' training at engineering university in physics laboratory in terms of problem-based approach. The feasibility of specially selected and developed tasks and problems is shown at the specified stages, interactive models, which improves the learning outcomes.

ANALYZING EMPLOYMENT OF HEI GRADUATES ACCORDING TO THE ENLARGED GROUPS OF SPECIALTIES

D.Yu. Baskakova, O.Yu. Belyash
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The article analyses indicators of Saint Petersburg HEIs graduates' employment according to the enlarged groups of specialties. The research allows determining groups of specialties with highest graduates' employment rate, as well as to allocate HEIs according to their graduates' employment rate within each enlarged group of specialties.

DIDACTIC CONDITIONS OF INDUSTRIALIZATION RISK MITIGATION IN ENGINEERING EDUCATION

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Tyumen Industrial University

The article deals with the issue of engineering education industrialization. The risks of engineering education industrialization are identified. The didactic conditions of their mitigation are grounded: arrangement and management of a student's autonomous work with possessed information (textbook) and raw information (research engineering data).

THE 50TH ANNIVERSARY OF VAZ: HIGHER EDUCATION IN TOGLIATTI AS AN INDICATOR OF INNOVATIVE DEVELOPMENT FOR PJSC "AVTOVAZ"

V.V. Eltsov, E.M. Chertakova
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The Volga Automobile Factory and Togliatti State University (TSU) were simultaneously founded. The development of both institutions was conditioned by mutual interaction in a number of aspects including scientific and research ones. The university contributed to the technical, technological and innovative solutions applied at the factory. It is also TSU that provided engineering staff for the factory. The modern condition of higher education in TSU reflects the same situation in PJSC "AVTOVAZ", that is system cri-ses in science and production. Both institutions have the same objective and subjective problems: the lack of funding for research, the cut of engineering structures (departments) at the factory, the decrease in university science ac-tivity, staff shortage, and subjective decisions made by top managers.

TRAINING STUDENTS TO MONITOR PRODUCT QUALITY IN CAD FOR CAR INDUSTRY

E.N. Pochekuev, V.V. Eltsov,
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Training of skilled specialists capable of designing qualitative products within the car industry could be hardly secured without the introduction of modern automated design systems into education programmes. Within the degree programme in "Mechanical Engineering", 15.03.01 offered by Togliatti State University Siemens PLM Software NX is applied. The proposed programme is comprehensive and aimed at product quality enhancement at the stage of product design. A great attention is also paid to evaluating the quality of the products subject to pressure shaping via CAE program Autoform, Deform and LS-DYNA.

MODERNIZATION OF PERSONNEL TRAINING FOR ECONOMIC DEVELOPMENT

V.P. Soloviev, T.A. Pereskokova
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This article considers the need to modernize the national system of training personnel with a university degree to ensure the growth of industrial output and the significant increase in the production of innovative products. The task of universities is to improve pedagogical skills of teachers so that they could efficiently use modern teaching technologies. Universities must generate students' fundamental competence, which is the commitment to quality. It is proposed to discuss new principal approaches to the system of education and upbringing. The article expresses the view that relatively soon the training of graduates with a Bachelor's degree in technical fields may hamper the development of modern innovative economy.

THE MISSION OF COMPETENCIES IN QUALITY MANAGEMENT DISCIPLINE AS A PART OF MASTER'S PROGRAMME "CIVIL CONSTRUCTION"

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Tyumen Industrial University

The article describes the role of competencies in mastering quality management discipline as a part of the master's degree programme "Civil Construction". The competencies are analyzed in accordance with the Federal State Education Standard 3+. In addition, the article presents the methodological bases of "Quality Management" discipline.

HUMANITARIAN MEANINGS OF ENGINEERING ACTIVITY AND THEIR ACTUALIZATION AMONG STUDENTS DURING UNIVERSITY EDUCATION PROCESS

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In modern education, the issue related to acquisition of axiological basis of engineering activity is still solved in compliance with knowledge approach. The authors substantiate the potential of integrating humanitarian and technical components of education content through activation of psychological and pedagogical mechanisms of meaning-making. This makes it possible to establish a meaningful axiological attitude among students - future engineers, to lay humanitarian meanings and values at the basis of their professional activity.

INTERACTIVE UNIFIED STATE EXAM TRAINING COMPLEXES

I.B. Docenko, V.V. Bur'kov, D.V. Bur'kov
South Federal University

The article presents the experience in implementing modern interactive tools, precisely unified state exam (USE) training complex, into school education. It describes the structure of the training complex and specific features of its integrated elements. The use of USE training complex for studying History of Russia is examined.

DEVELOPMENT OF CREATIVE GRAPHIC SKILLS

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The article considers the current problems of teaching descriptive geometry for engineering students at the Russian universities. The key objectives of descriptive geometry course are shown. Modern conditions of teaching the course are described in terms of Russia's accession to the Bologna process.

MANAGEMENT THE WRITING OF BACHELOR'S GRADUATE QUALIFICATION WORK IN CONSTRUCTION BASED ON TECHNOLOGY OF END-TO-END COURSE PROJECT

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To resolve the issue of high-quality training of graduates in the field of Construction, in order to perform complex engineering activities, it is required to adopt new educational technologies and organizational forms of training. This article presents the implementation model of Bachelor's Graduate Qualification Work in Construction, as per IDEF0 methodology. The model is based on the technology of end-to-end course project work. The article demonstrates positive results of the model implementation in the learning process.

FOREIGN LANGUAGE TEACHING WITHIN "AIRCRAFT ENGINEERING" PROGRAMME

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The article discusses the issue of enhancing the quality of foreign language teaching at engineering university. Within the education programme "Aircraft Engineering", this issue is of particular importance due to the current situation in this economy sector. The article examines the problems of foreign language teaching, describes and postulates the language teaching system developed at Samara University.

STUDENTS' GRAPHICAL CULTURE DEVELOPMENT IN THE UNIVERSITY VIRTUAL LEARNING SPACE

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The article analyzes the problems related to the development of students' graphical culture in modern virtual environment of an engineering university. Graphical culture is defined as a matureness of productive professional competencies shaped within the virtual learning space of a university. They include broad-based graphical knowledge and graphic design thesaurus.

CONTINUOUS MASTERING OF COMPUTER TECHNOLOGIES AS A MANDATORY CONDITION FOR HIGHLY QUALIFIED SPECIALISTS' EDUCATION IN THE SPHERE OF OPTICAL ENGINEERING AND ELECTROOPTIC INSTRUMENT ENGINEERING

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Moscow State University of Geodesy and Cartography (MIIGAiK)

Specialists' training in the sphere of optical engineering and electrooptic instrument engineering can be divided into three stages from the standpoint of using information and computer technologies: 1. Study of general principles of information and computer technologies; 2. Mastering these technologies in design of typed blocks of optic and electrooptic systems; 3. Instruction in computer modelling based on systematic approach to designing electrooptic complexes as a whole.

Professional and Public Accreditation of Educational Programmes (Results)

Over the past 20 years, Association for Engineering Education of Russia (AEER) has been developing the system of professional and public accreditation of engineering and technology programmes in Russia.

AEER is a member of the most authoritative international organizations involved in engineering programme accreditation: International Engineering Alliance, Washington Accord, European Network for Accreditation of Engineering Education (ENAEE). AEER is the only national organization entitled to assign the international certification label (EUR -ACE label) for accredited programmes.

The system of professional and public accreditation of engineering programmes developed and implemented by AEER is now international and accepted in the majority of developed countries.

By December 21, 2017, AEER has accredited 511 educational programmes (first and second cycles) provided by 75 leading universities of Russia, Kazakhstan, Kirgizstan, Tajikistan, and Uzbekistan. The European certification label EUR-ACE has been awarded to 429 programmes. Also, 5 secondary vocational education programmes provided by Russian vocational training colleges have been accredited. The lists of educational programmes accredited by AEER are regularly submitted to Federal Education and Science Supervision Service and reported to the signatories of Washington Accord and ENAEE.

International accreditation of the educational programmes improves the image of Russian education on the global market, and makes national universities more attractive both for Russian and foreign students. It intensifies academic mobility and development of international cooperative education programmes. Graduating from an accredited institution allows young professionals to be recognized by APEC and FEANI engineer registers.

The following Register shows the educational programmes accredited by AEER.

List of Accredited Programmes, Russian Federation (as of 21.12.2017)

	Programme Code	Qualification	Programme 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
5.	151900 (15.03.05)	FCD	Design Engineering Solutions for Mechanical Engineering Industries	AEER EUR-ACE®	2015-2020
	Bashkir State Agrarian University				
1.	13.03.01	FCD	Energy Supply of Enterprises	AEER EUR-ACE®	2017-2022
2.	23.03.03	FCD	Automobiles and Automobile Industry	AEER EUR-ACE®	2017-2022
	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 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
9.	19.03.04	FCD	Technology of Production and Catering	AEER EUR-ACE®	2016-2021
10.	38.03.05	FCD	Enterprise Architecture	AEER EUR-ACE®	2016-2021
11.	22.03.01	FCD	Materials Science and Technology of new Materials	AEER EUR-ACE®	2016-2021
12.	22.04.01	SCD	Constructional Nanomaterials	AEER EUR-ACE®	2016-2021
	Belgorod State Technological University named after V.G. Shukhov				
1.	08.04.01 (270800.68)	SCD	Nanosystems in Building Materials Science	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
	Don State Technical University				
1.	12.03.04	FCD	Engineering in Biomedical Practice	AEER EUR-ACE®	2016-2021
2.	20.03.01	FCD	Safety of Technological Processes and Production	AEER EUR-ACE®	2016-2021
3.	20.03.01	FCD	Environmental Protection	AEER EUR-ACE®	2016-2021
4.	13.03.03	FCD	Hydraulic, Vacuum and Compressor Equipment	AEER EUR-ACE®	2016-2021

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
5.	15.03.04	FCD	Automation of Technological Processes and Productions in Machine Building	AEER EUR-ACE®	2017-2022
6.	15.04.02	SCD	Processes and Devices of Food Production	AEER EUR-ACE®	2017-2022
7.	15.03.06	FCD	Mechatronics	AEER EUR-ACE®	2017-2022
8.	15.03.06	FCD	Robots and Robotic Systems	AEER EUR-ACE®	2017-2022
9.	15.04.05	SCD	Technological Support of Quality of Products of Mechanical Engineering	AEER EUR-ACE®	2017-2022
10.	15.04.05	SCD	Technological Design of Machine-Building Production	AEER EUR-ACE®	2017-2022
	Gubkin Russian State University of Oil and Gas (National Research University)				
1.	21.03.01	FCD	Construction and Repair of Pipeline Transport Systems	AEER EUR-ACE®	2016-2021
2.	21.03.01	FCD	Operation and Maintenance of Facilities of Transportation and Storage of Oil, Gas and Refined Products	AEER EUR-ACE®	2016-2021
3.	21.03.01	FCD	Development and Service of Gas/Gas Condensate Production Facilities and Underground Storage	AEER EUR-ACE®	2016-2021
4.	21.03.01	FCD	Drilling of Oil and Gas Wells	AEER EUR-ACE®	2016-2021
5.	21.03.01	FCD	Development and Maintenance of Petroleum Production Facilities	AEER EUR-ACE®	2016-2021
	National Research University Higher School of Economics				
1.	11.04.04	SCD	Electronic Engineering	AEER EUR-ACE®	2015-2020
2.	11.04.04	SCD	Measurement Technologies of Nanoindustry	AEER EUR-ACE®	2015-2020
3.	09.03.01	FCD	Information Science and Computation Technology	AEER EUR-ACE®	2016-2021
4.	09.04.01	SCD	Computer Systems and Networks	AEER EUR-ACE®	2016-2021
5.	01.03.04	FCD	Applied Mathematics	AEER EUR-ACE®	2016-2021
6.	01.04.04	SCD	Management Systems and Information Processing in Engineering	AEER EUR-ACE®	2016-2021
	Immanuel Kant Baltic Federal University				
1.	23.03.01	FCD	Organization of Road Transportation	AEER EUR-ACE®	2016-2019
	Irkutsk National Research 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
8.	15.04.01	SCD	Technology, Equipment and Quality System for Welding	AEER EUR-ACE®	2015-2020
9.	20.04.01	SCD	Fire Protection	AEER EUR-ACE®	2015-2020
10.	15.04.02	SCD	Food Engineering	AEER EUR-ACE®	2015-2020
11.	20.04.01	SCD	Population Saving, Occupational, Environmental and Disaster Risk Management	AEER EUR-ACE®	2015-2020
12.	13.04.02	SCD	Intelligent Power Systems	AEER EUR-ACE®	2017-2022
13.	13.04.02	SCD	Renewable energy	AEER EUR-ACE®	2017-2022
14.	07.04.01	SCD	Architecture of the Sustainable Environment	AEER EUR-ACE®	2017-2022

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
15.	07.04.04	SCD	Urban Landscape Planning	AEER EUR-ACE®	2017-2022
16.	08.04.01	SCD	Innovative Water Supply and Wastewater Technologies	AEER EUR-ACE®	2017-2022
	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
	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
3.	28.04.02	SCD	Nanostructured Natural and Synthetic Materials	AEER EUR-ACE®	2015-2020
	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

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	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
	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
3.	11.04.04	SCD	Components of Nanoelectronics	AEER EUR-ACE®	2017-2022
4.	11.04.04	SCD	Microelectronics and Solid State Electronics	AEER EUR-ACE®	2017-2022
5.	11.04.04	SCD	Design Automation for Submicron ASIC and System-on-Chip	AEER EUR-ACE®	2017-2022
6.	11.04.04	SCD	Materials and technology of Functional Electronics	AEER EUR-ACE®	2017-2022
	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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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
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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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
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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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 Tomsk State University				
1.	12.04.03	SCD	Appliances and Devices in Nanophotonics	AEER EUR-ACE®	2015-2020
2.	15.04.03	SCD	The Mechanics of Biocomposites, the Production and Modeling of their Structures and Properties	AEER EUR-ACE®	2016-2021
3.	16.04.01	SCD	Macrokinetics of Combustion of High Energy Materials	AEER EUR-ACE®	2016-2021
4.	12.04.02	SCD	Optical and Optoelectronic Devices	AEER EUR-ACE®	2016-2021
5.	01.04.01	SCD	Pure Mathematics	AEER EUR-ACE®	2017-2022
6.	03.04.03	SCD	Radiophysics, Electronics and Information Systems	AEER EUR-ACE®	2017-2022
	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
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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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® WA	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
7.	21.05.02	INT	Geology of Oil and Gas	AEER EUR-ACE® WA	2015-2020
8.	21.05.03	INT	Geophysical Methods for Well Exploration	AEER EUR-ACE® WA	2015-2020
9.	23.04.03	SCD	Technical Exploitation of Automobiles	AEER EUR-ACE®	2015-2020
10.	23.03.03	FCD	Automobiles and Vehicle Fleet	AEER EUR-ACE®	2015-2020
11.	09.04.03	SCD	Knowledge Management	AEER EUR-ACE®	2015-2020
12.	10.04.01	SCD	Comprehensive Protection for Computerization Facilities	AEER EUR-ACE®	2015-2020
13.	11.03.02	FCD	Communication network and Switching Systems	AEER EUR-ACE®	2015-2020
14.	11.03.04	FCD	Industrial electronics	AEER EUR-ACE®	2017-2022
15.	11.04.04	SCD	Physical Electronics	AEER EUR-ACE®	2017-2022
16.	09.04.02	SCD	Data Management	AEER EUR-ACE®	2017-2022
17.	10.05.01	INT	Information Security of Objects of Information Based on Computer Systems	AEER EUR-ACE® WA	2017-2022
18.	15.03.05	FCD	Technology of Mechanical Engineering	AEER EUR-ACE®	2017-2022
19.	15.04.02	SCD	Processes and Apparatuses of Food Engineering	AEER EUR-ACE®	2017-2022
20.	21.03.01	FCD	Operation and Maintenance of Oil Production Facilities	AEER EUR-ACE®	2017-2022
21.	20.04.01	SCD	Emergency Protection	AEER EUR-ACE®	2017-2022
22.	22.03.01	FCD	Materials Science and Technology of Nanomaterials and Nanosystems	AEER EUR-ACE®	2017-2022
23.	22.04.01	SCD	Materials Science and Technology of Nanomaterials and Nanosystems	AEER EUR-ACE®	2017-2022

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Institute of Service, Tourism and Design (Branch of North-Caucasus Federal University in Pyatigorsk)				
1.	27.03.04	FCD	Management and Computer Science in Technical Systems	AEER EUR-ACE®	2015-2020
2.	23.03.03	FCD	Automobile Service	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
2.	16.04.01	SCD	Laser Science and Technology	AEER EUR-ACE®	2015-2020
3.	22.04.01	SCD	Material Science, Technology and Processing of Materials with Specific Properties	AEER EUR-ACE®	2015-2020
4.	28.04.01	SCD	Micro- and Nanosystem Engineering Materials	AEER EUR-ACE®	2015-2020
5.	22.03.01	FCD	Material Science and Technologies of Engineering Materials	AEER EUR-ACE®	2017-2022
6.	13.03.02	FCD	Power Engineering	AEER EUR-ACE®	2017-2022
	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
3.	11.04.04	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
	Omsk State Technical University				
1.	28.04.02	SCD	Nanoengineering	AEER EUR-ACE®	2017-2022
	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
6.	151900	SCD	Automated Engineering Technology	AEER EUR-ACE®	2015-2020
7.	220400	SCD	Intellectualization and Optimization of Control Processes	AEER EUR-ACE®	2015-2020

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	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
3.	27.04.04 (220400.68)	SCD	Distributed Computing Information and Control Systems	AEER EUR-ACE®	2015-2020
	Petrozavodsk State University				
1.	210100	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
	Samara National Research University (before April 6, 2016 – Samara State Aerospace 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
7.	11.04.01	SCD	GNSS receivers. Hardware and software	AEER EUR-ACE®	2017-2022
8.	22.04.02	SCD	Innovative Technologies for Obtaining and Processing Materials with Specified Properties	AEER EUR-ACE®	2017-2022
9.	24.04.01	SCD	Design and Construction of Space Monitoring and Transportation Systems	AEER EUR-ACE®	2017-2022
10.	24.05.02	INT	Innovative Technologies of Rocket Engine Construction	AEER EUR-ACE® WA	2017-2022
11.	25.03.01	FCD	Technical Maintenance of Aircrafts and Engines	AEER EUR-ACE®	2017-2022
	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
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

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
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
29.	11.04.01	SCD	Radiolocation of Objects and Environments	AEER EUR-ACE®	2015-2020
30.	11.04.01	SCD	Microwave, Optical, and Digital Telecommunications Hardware	AEER EUR-ACE®	2015-2020
31.	11.04.01	SCD	Infocommunication Technology in Space Patterns Analysis and Processing	AEER EUR-ACE®	2015-2020
32.	13.04.02	SCD	Electrotechnologies	AEER EUR-ACE®	2015-2020
33.	12.04.01	SCD	Devices and Methods of Quality Control and Diagnostics	AEER EUR-ACE®	2015-2020
34.	12.04.01	SCD	Lazer Measurement Technologies	AEER EUR-ACE®	2015-2020
35.	12.04.01	SCD	Adaptive Measuring Systems	AEER EUR-ACE®	2015-2020
36.	27.04.02	SCD	Integrated Quality Management Systems	AEER EUR-ACE®	2015-2020
37.	11.04.04	SCD	Heterostructure Solar Photovoltaics	AEER EUR-ACE®	2015-2020
38.	28.04.01	SCD	Nano- and Microsystem Engineering	AEER EUR-ACE®	2015-2020
39.	09.04.02	SCD	Distributed Computing Systems of Real-Time	AEER EUR-ACE®	2015-2020
40.	27.04.04	SCD	Control and Information Technologies in Technical Systems	AEER EUR-ACE®	2015-2020
41.	11.04.01	SCD	Radionavigation Systems	AEER EUR-ACE®	2017-2022
42.	11.04.03	SCD	Information Technologies of Designing of Radio-Electronic Means	AEER EUR-ACE®	2017-2022
43.	11.04.03	SCD	Microwave Engineering	AEER EUR-ACE®	2017-2022
44.	11.04.04	SCD	Quantum and Optical Electronics	AEER EUR-ACE®	2017-2022
45.	28.04.01	SCD	Nanotechnology and Diagnostics	AEER EUR-ACE®	2017-2022
46.	09.04.01	SCD	Software of Information and Computing Systems	AEER EUR-ACE®	2017-2022
47.	09.04.01	SCD	Computer-Aided Design in Electronics and Engineering	AEER EUR-ACE®	2017-2022
48.	12.04.01	SCD	Acoustic Devices and Systems	AEER EUR-ACE®	2017-2022

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
49.	12.04.01	SCD	Integrated Navigation Technologies	AEER EUR-ACE®	2017-2022
50.	12.04.01	SCD	Local Measuring and Computing Systems	AEER EUR-ACE®	2017-2022
	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
9.	12.04.01	SCD	Methods of Diagnosis and Analysis in Bionanotechnology	AEER EUR-ACE®	2015-2020
10.	12.04.01	SCD	Devices for Research and Modification of Materials at the Micro- and Nanoscale Level	AEER EUR-ACE®	2015-2020
11.	12.04.03	SCD	Metamaterials	AEER EUR-ACE®	2015-2020
12.	12.04.03	SCD	Nanomaterials and Nanotechnologies for Photonics and Optoinformatics	AEER EUR-ACE®	2015-2020
13.	12.04.03	SCD	Optics of Nanostructures	AEER EUR-ACE®	2015-2020
14.	11.04.02	SCD	Nanotechnologies in Fiber Optics	AEER EUR-ACE®	2017-2022
15.	12.04.02	SCD	LED Technology	AEER EUR-ACE®	2017-2022
16.	01.04.02	SCD	Supercomputing Technologies in Interdisciplinary Research	AEER EUR-ACE®	2017-2022
17.	15.04.06	SCD	Intelligent Technologies in Robotics	AEER EUR-ACE®	2017-2022
18.	16.04.03	SCD	Industrial Refrigeration Systems and Heat Pumps	AEER EUR-ACE®	2017-2022
	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
	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

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
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 Transport University				
1.	23.05.06	INT	Bridges	AEER EUR-ACE® WA	2017-2022
	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
3.	09.03.02	FCD	Information Systems and Technologies	AEER EUR-ACE®	2015-2020
4.	09.03.04	FCD	Software Engineering	AEER EUR-ACE®	2015-2020
5.	15.03.04	FCD	Automation of Technological Processes and Productions	AEER EUR-ACE®	2015-2020
	Siberian Federal University Sayano-Shushensky Branch				
1.	08.03.01	FCD	Hydrotechnical Construction	AEER EUR-ACE®	2016-2021
	Southwest State University				
1.	28.04.01	SCD	Nanotechnology	AEER EUR-ACE®	2015-2020
	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
3.	28.03.02	FCD	Engineering Nanotechnologies in Machine Building	AEER EUR-ACE®	2017-2022
	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
4.	22.04.01	SCD	Welding and Soldering of Advanced Metal and Non-Metal Inorganic Materials	AEER EUR-ACE®	2012-2014

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
5.	22.04.01	SCD	Material Science and Technologies of Nanomaterials and Coatings	AEER EUR-ACE®	2016-2021
6.	20.04.01	SCD	Productional, Industrial and Environmental Safety Management Systems	AEER EUR-ACE®	2016-2021
7.	15.04.05	SCD	Computer-Aided Engineering Technology	AEER EUR-ACE®	2016-2021
8.	13.04.02	SCD	Operating Modes of Electric Power Supplies, Substations, Circuits and Systems	AEER EUR-ACE®	2016-2021
	Tomsk State University of Architecture and Building				
1.	08.03.01	FCD	Industrial and Civil Engineering	AEER EUR-ACE®	2017-2022
2.	08.04.01	SCD	Modern Technologies in Design and Civil Engineering	AEER EUR-ACE®	2017-2022
	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
3.	11.04.04	SCD	Solid-State Electronics	AEER EUR-ACE®	2016-2021
4.	11.05.01	INT	Radio-electronic Systems of Space Complexes	AEER	2017-2022
	Transbaikal State University				
1.	21.05.04 (130400.65)	INT	Open Mining	AEER EUR-ACE® WA	2015-2020
2.	08.05.01 (271101.65)	INT	Construction of High-Rise and Long-Span Buildings and Structures	AEER EUR-ACE® WA	2015-2020
	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
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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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® WA	2008-2013 2012-2013
2.	210100	SCD	Electronics and Nanoelectronics	AEER EUR-ACE®	2015-2020
3.	221700	SCD	Standardization and Metrology	AEER EUR-ACE®	2015-2020
4.	22.04.01	SCD	Material Science, Technology Acquisition and Processing of Metal Materials with Special Properties	AEER EUR-ACE®	2015-2020
5.	22.04.01	SCD	Materials Science, Production Technology and Processing of Non-Ferrous Alloys	AEER EUR-ACE®	2015-2020
6.	22.04.01	SCD	Material Science and Materials Technology in the Nuclear Energy Industry	AEER EUR-ACE®	2015-2020
7.	28.04.01	SCD	Materials of Micro- and Nanosystem Techniques	AEER EUR-ACE®	2017-2022
8.	08.04.01	SCD	Production of Construction Materials and Products	AEER EUR-ACE®	2017-2022
	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
5.	28.04.02	SCD	Nanoengineering is the Machinery	AEER EUR-ACE®	2017-2022
6.	22.04.01	SCD	Material Science and Technology of new Materials	AEER EUR-ACE®	2017-2022
7.	11.04.04	SCD	Industrial Electronics	AEER EUR-ACE®	2017-2022
	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

	Programme Code	Qualifi-cation	Programme 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
18.	18.03.01	FCD	Chemical Technology of Natural Energy Carriers and Carbon Materials	AEER EUR-ACE®	2015-2020
19.	18.04.01	SCD	Chemistry and Technology of Basic Organic and Petrochemical Synthesis Products	AEER EUR-ACE®	2015-2020
20.	19.04.01	SCD	Industrial Biotechnology and Bioengineering	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
3.	200400	SCD	Laser Devices and Systems	AEER EUR-ACE®	2015-2020
4.	12.04.05	SCD	Solid-State and Semiconductor Laser Systems	AEER EUR-ACE®	2016-2021
	Volga State University of Technology				
1.	15.03.01 (150700)	FCD	Machine Building	AEER EUR-ACE®	2015-2020
2.	11.03.02 (210700)	FCD	Information and Communication Technologies and Telecommunication Systems	AEER EUR-ACE®	2015-2020
	Voronezh State University				
1.	03.03.02	FCD	Solid State Physics	AEER EUR-ACE®	2017-2020
2.	03.04.02	SCD	Physics of Nanosystems	AEER EUR-ACE®	2017-2020
3.	11.03.04	FCD	Nanotechnology in Electronics	AEER EUR-ACE®	2017-2020
4.	11.04.04	SCD	Nanotechnology in Electronics	AEER EUR-ACE®	2017-2020
5.	11.03.04	FCD	Integrated Electronics and Nanoelectronics	AEER EUR-ACE®	2017-2020
6.	11.04.04	SCD	Integrated Electronics and Nanoelectronics	AEER EUR-ACE®	2017-2020

List of Accredited Programmes, Republic of Kazakhstan (as of 01.06.2017)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	D. Serikbayev East Kazakhstan State Technical University				
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				
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				
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				
1.	050704	FCD	Computer Science and Software	AEER EUR-ACE®	2010-2015
2.	050711	FCD	Geodesy and Cartography	AEER EUR-ACE®	2010-2015
3.	050712	FCD	Mechanical Engineering	AEER EUR-ACE®	2010-2015
4.	050718	FCD	Electrical Power Engineering	AEER EUR-ACE®	2010-2015
5.	050723	FCD	Technical Physics	AEER EUR-ACE®	2010-2013
6.	050713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2011-2016
7.	050716	FCD	Instrumentation Engineering	AEER EUR-ACE®	2011-2016
8.	050719	FCD	Radio Engineering, Electronics and Telecommunications	AEER EUR-ACE®	2011-2016
9.	050720	FCD	Chemical Technology of Inorganic Substances	AEER EUR-ACE®	2011-2016
10.	050721	FCD	Chemical Technology of Organic Substances	AEER EUR-ACE®	2011-2016
11.	050722	FCD	Printing	AEER EUR-ACE®	2011-2016
12.	050724	FCD	Processing Machinery and Equipment	AEER EUR-ACE®	2011-2016
13.	050729	FCD	Construction	AEER EUR-ACE®	2011-2016
14.	050731	FCD	Life Safety and Environmental Protection	AEER EUR-ACE®	2011-2016
15.	050732	FCD	Standardization, Metrology and Certification	AEER EUR-ACE®	2011-2016
	Karaganda State Technical University				
1.	050702	FCD	Automation and Control	AEER EUR-ACE®	2010-2015
2.	050707	FCD	Mining Engineering	AEER EUR-ACE®	2010-2015
3.	050709	FCD	Metallurgy	AEER EUR-ACE®	2010-2015
4.	050712	FCD	Mechanical Engineering	AEER EUR-ACE®	2010-2015
5.	050713	FCD	Transport, Transport Facilities and Technology	AEER EUR-ACE®	2010-2015
	Kostanay Engineering and Pedagogical University				
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				
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 Programmes, Kyrgyzstan (as of 21.12.2017)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Kyrgyz State Technical University named after I. Razzakov				
1.	690300	FCD	Communication Networks and Switching Systems	AEER EUR-ACE®	2015-2020
	Kyrgyz State University of Construction, Transport and Architecture named after N. Isanov				
1.	750500	FCD	Industrial and Civil Engineering	AEER EUR-ACE®	2015-2020

List of Accredited Programmes, Tajikistan (as of 21.12.2017)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Tajik Technical University named after Academician M.S. Osimi				
1.	700201	FCD	Design of Buildings and Constructions	AEER EUR-ACE®	2015-2020
2.	430101	SCD	Electrical Stations	AEER EUR-ACE®	2015-2020

List of Accredited Programmes, Uzbekistan (as of 21.12.2017)

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Tashkent State Technical University named after Abu Raykhan Beruniy				
1.	5310800	FCD	Electronics and Instrumentation	AEER EUR-ACE®	2015-2020

List of Accredited Secondary Professional Education Programmes (as of 21.12.2017)

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	Starooskolsky Technology Institute named after A.A. Ugarov (branch) National University of Science and Technology "MISIS" (MISIS)				
1.	13.02.11	T	Technical operation and maintenance of electrical and electromechanical equipment (by industry)	AEER	2016-2021
2.	22.02.01	T	Metallurgy of ferrous metals	AEER	2016-2021
	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 Programmes – 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/

European Network for Accreditation of Engineering Education

ENAEE

European Accreditation of Engineering Programmes EUR-ACE®

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

ENGINEERING EDUCATION 22'2017

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**

ENGINEERING EDUCATION

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