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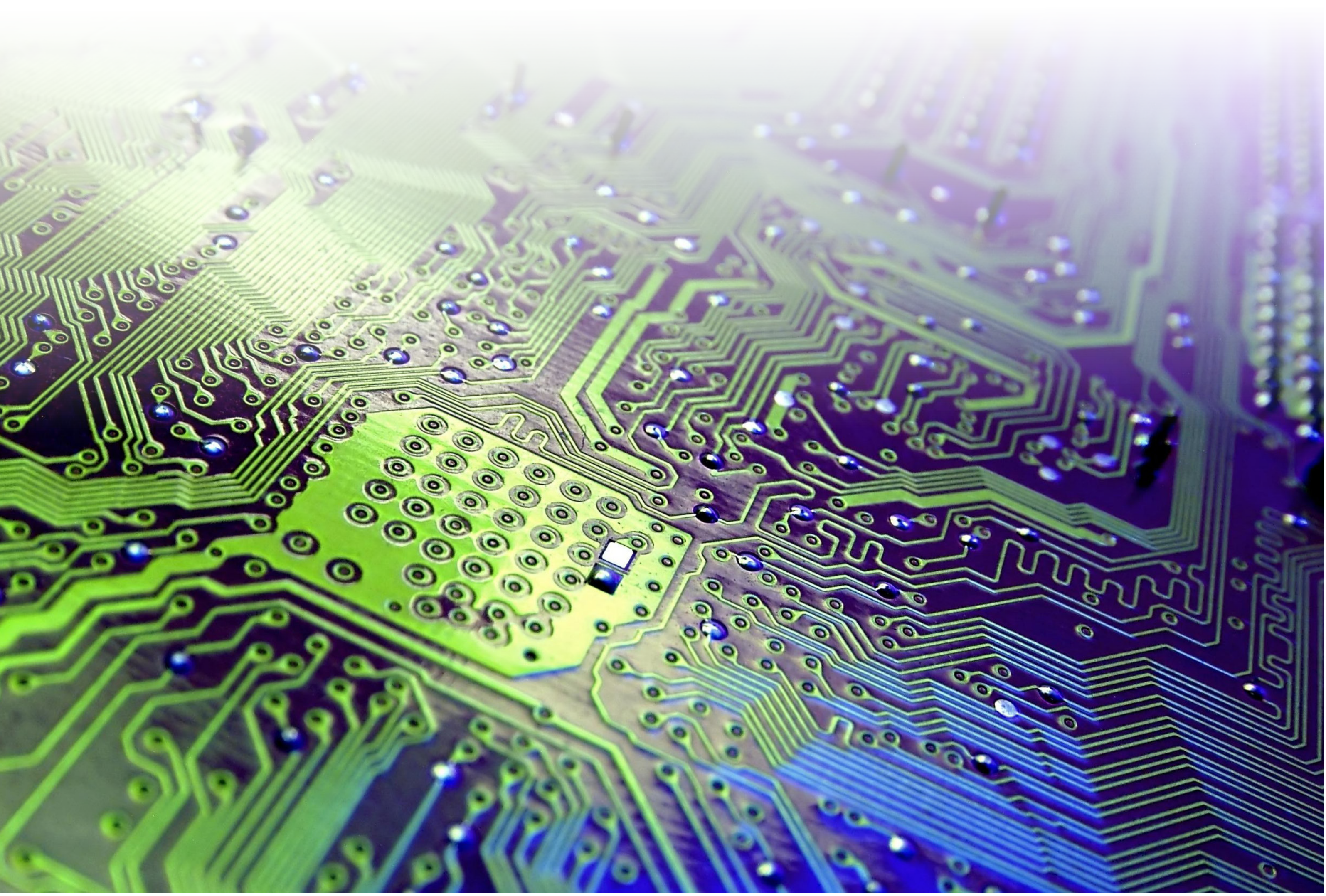

ENGINEERING EDUCATION: ASPECTS AND METHODS

Editorial board

Dear readers!

The challenges of the external and internal environment to Russian and world engineering education become more acute not only with the development of engineering and technology but also in connection with the changing social and economic relations in society. We can clearly see how the requirements for specialists in the field of engineering and technology trained in higher education institutions are changing. These changes deal with both professional competencies and soft skills outlining the ability to organize engineering activities, work in a team and be open-minded, the ability to see, formulate and find the solution of engineering problems.

In an attempt to find a way out of existing and emerging situations, the engineering and academic professional community takes various initiatives. Wavy, but the continuous interest of the community in such initiatives and approaches as CDIO, interdisciplinarity, practice-oriented, problem-based and project-based learning, professional standards, outcome-based approach, etc. demonstrates that all the problems mainly concern the improvement of content and educational technologies in engineering education. To a lesser extent, this interest is concentrated on the education management system. Despite all these initiatives, the “classroom lessons” system continues to dominate in the training system of future engineers. The knowledge component in the training process prevails over the active component. At the same time, the requirements to competencies and skills of graduates are raised, which are precisely need to be formed following active learning approach. The situation is aggravated by the lack of coherent and adequate methods for assessing competencies within the training process at HEI and upon graduation. The transition to the two-tier education of future engineers still causes discussions in the professional environment, due to the lack of a coherent strategy for managing the training of specialists for professional engineering activities. In these conditions, the professional scientific and educational communities have to work concentrating their efforts on improving engineering education, adapting its content and educational technologies not only to the requirements of the modern engineering community but also to stochastically changing bureaucratic requirements. The avalanche-like increase in the number of required papers regulating the educational process not only does not provide an avalanche-like improvement in the quality of training of future specialists but, on the contrary, reduces the opportunity to increase this quality, encroach upon teachers' time that they really could use for solving this problem.

This issue of the journal offers readers to get acquainted with the results of reflection, analysis, use of methods and techniques in engineering education, reproduction of engineers, quality assurance of training by improving educational technologies.

We hope that the articles of our authors will help readers to find answers to their questions in the field of engineering education.

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

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A.A. Dul'zon

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Higher Education Reforms and Academic Community

National Research Tomsk Polytechnic University
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The paper aims at drawing academic community's and authority's attention to the systemic crisis of Russian higher education and the necessity for country-wide discussion to find rational crisis recovery. It studies the reasons and propagation of the crisis in the higher education and provides some solutions to overcome the problem. It underlines the necessity to involve wider academic community and Russian society in development of technologies to overcome crisis. The relevance of higher education institutions consolidation is put under reasonable doubt. The author highlights the necessity of balanced approach to the competition in the education system, with turning focus on comprehensive cooperation at all levels. The article suggests initial steps to ensure basic conditions for stability and further improvement of the university system efficiency. Therewith, it is crucial to ensure high standards of ethics and integrity of the academic community and management staff of the universities.

Key words: higher education crisis, consolidation of higher education institutions, balance between competition and cooperation, increasing university efficiency.

Origin, causes and factors of crisis in Russian higher education

Higher education reforms are occasionally carried out in all countries, when there is a need to adjust it to economical and social changes. However, there is hardly any country except Russia with the reforms being constantly carried out for twenty five years. Although the Soviet higher school kept training at high level, by the 1970–1980, it had had some serious problems that required new solutions.

A transition from the state-controlled to market economy was a ground reason to revise and correct basic principles of the national policy and legal regulations in education. However, the on-going process of the reform leaves perplexed or even strong rejection from the academic community, which constitutes the main part of the national intellectual elite.

The conditions for the educational reform in the "wild 90s" were extremely adverse. Artificially induced bankruptcy of the national industry and agriculture, which was caused by state-demand abandonment and tariff growth, practically stopped the whole economy development of the country. It was a good opportunity for a narrow circle of persons (some people) to plunder the national wealth. In the beginning of the 90s, there were about 500 state universities in Russia. They became bankrupts as well, since they could not pay utility bills. However, the government did not privatize them, but founded 1.5 thousand more universities and affiliated branches.

The total number of students in USSR universities at the end of the 80s was about 2.5 billion people. In early the 2000s, it reached 7.5 billion students only in Russia. Therewith, there was no lack of specialists for the new economy, since several hundred thousand highly qualified specialists had been dismissed from military and other manufacturing sectors.

The only logical explanation for this phenomenon, which seems to be strange, however, is that the authority aimed at keeping the youth busy with something, but not at introducing total higher education in

Russia. In this regard, the authorities' action at that moment can be regarded as effective. Even today that decision can be assessed as a rational one; otherwise, there might have been extensive unrest and deaths of young people. Mass unemployment would have hardly made people loyal to the authorities, and "Maidans" in all big Russian cities would have been easily predicted. To suppress the riots, the military force would have been used. "In other words, it is easier and cheaper to make a person socialize in university than in prison" [1, p. 75].

In those years the author hoped that it was universities that would be a base for revitalization of the society's moral foundation, since they had concentrated a considerable part of the nation's intelligence. The universities should have actively participated in establishing a positive value system that had been notably destroyed in the 90-s as the future of the country is highly dependent on leaders and managers of enterprises, former university graduates.

The faculty staff, for whom teaching and science were a calling, kept on working faithfully for some time as a result of inertia. The faculty's performance degraded due to some factors, the key one being extremely low salary. It led to a faculty's status decline, which had a negative impact on students' attitude to the faculty, as well as faculty's attitude to their responsibilities. When taking the position of the First Vice Rector, the author used to hear from the faculty something like: "You should be thankful for my coming to work for such a salary, how can you ask me for something more!"

Paltry salaries forced the faculty to undertake additional work, which was at the expense of educational process.

Sharp increase in the amount of students, changes in students' values and aims had a negative influence on the learning outcomes and training quality. While most of soviet students entered universities for study, in the 90-s such students were in minority. An anonymous questionnaire conducted by the author in 2001 in TPU showed that only 20% of the students were motivated to study. The most typical reasons for entering university were "to get a diploma", "to avoid the army", "my parents' decision", "to start a family", " to avoid parental control and care", and "to be funded by parents". There was even such a unique answer as "to deal in the campus".

Under such circumstances most part of the faculty lost motivation to efficient training activity. As a result, most of the students pretended to study while many teachers pretended to teach. Thus, Ya.I. Kuz'minov et al. admit that "... there are universities in all the studied groups, except the group of research universities, where the educational process is only imitated in a considerable part of education programmes" [2, p. 53].

The transition to the Anglo-Saxon education system, the integration in the Bologna process, and continuous changes in education standards and programmes contributed more to the disorganization of the training process. The training quality kept on degrading. The article by D. Sandakov clearly describes the technology used to ruin higher education with "ex adverso" method [3]. It should be noted that it took ten years and additional funding for German universities, which are in favorable economic conditions, to transfer to two-level education system. In Russia, this transition was carried out top-bottom, within short timeframes, without appropriate funding.

The Bologna process became a logical step for the European Union with its united labour market. However, it is still disputable if this process is suitable for Russia. Nevertheless, the analysis of the primary documents of the Bologna process proves that the Bologna "programme of action" can bring a lot of benefits to the Russian higher education reform. It is quite natural that not all the goals are equally important both for Russia and for the EU. For example, in Russia it is more important to raise a citizen of Russia rather than that of Europe. The mechanism of reform implementation is a complicated issue as well, which is also noted by European experts. They underline the necessity to take into account the state's interests (implying that state's and public interests should match) and to preserve historical, cultural and language diversity. A blatant adjustment of the national higher education system to the "Bologna frame" can result in its degradation and destruction [4].

The financial supply of the Russian higher education system has been gradually improved since the beginning of the 2000-s. However, the general condition of the education sphere in Russia is still unsatisfying. The most topical problems were clearly covered in a number of critical articles [5–7]. Some statements being disputable, however, the general situation is quite true. Although the methods suggested by D. Fomin seem to be too severe and remind the repressions of the 1930-s, we cannot pretend that everything has become better.

Unfortunately, these articles did not cause an active discussion in academic community. So far there has not been any true national debate on condition and problems of higher education system in Russia.

Current reforms and their contradictions

Thus, the assessments of Russian higher education in the first decade of the current century range from "has stopped existing" [6] to "a serious systemic crisis" [7]. Someone thinks that it cannot be reformed. The suggested solutions vary from destructing the existing system and establishing something absolutely new to returning back to the Soviet higher education system, the latter being a non-constructive waste of time and efforts. According to the principle of time irreversibility, a complex dynamic system cannot be stable in changing environment as well as return to the initial state [8]. However, it does not mean that we should blindly follow the Anglo-Saxon education system and ignore the positive experience of the soviet education [9].

There is some reason for being optimistic if we take into account the fact that a significant part of faculty (especially in old universities) still remains strongly committed to the value-based approach to education. The examples are Ogarev Mordovia State University, Tyumen State Oil and Gas University [10–12]. It must be pleasure to work in such teams.

The problems of reforms in higher education are actively and in detail discussed in journals "University management" (in Russ.) [13–15], "Higher education in Russia" (in Russ.) [16], "Higher education today" (in Russ.) [17], "Education issues" (in Russ.) [2], etc. "The Strategy-2020" was published though not implemented [18]. A foresight research "The future of Russian higher school till 2030" was conducted [19]. It may seem that there is no lack of information in the discussed issue, but it is not true. Since the reforms are top-bottom and are very controversial, the academic community and Russian society have no valid information about the on-going processes, and what is more important, about their goals and methods. We can only guess about the reasons of the "hazy fog" that makes an open public discussion impossible. "It is difficult to limit pseudo-education, since direct measures (like graduates' competency assessment, the closure of universities resulted from monitoring etc.) would influence most part of the education programmes and students, which is socially unacceptable for the authorities. The indirect measures are inefficient." [2, p. 53]. In any case, the faculty and academic community have many questions and doubts.

Some authors, neglecting the socialistic ideology and soviet education system, hold up as an example the Anglo-Saxon education system and social achievements of the capitalistic world. They highlight the weaknesses of the soviet education system without mentioning its strength and positive experience. These authors don not notice that they have joined the ideology that is as doubtful as the soviet one. It has resulted in the current global problems that make concerned even such an apologist of capitalism as Albert Gore (junior) [20].

There is no doubt that it is desirable to intensify a systemic search for optimal institutional structure of the Russian higher education system due to inner and outer changes in conditions of its functioning. However, the academic community are concerned with such "intensification", since "gurus" of Higher School of Economics declare principles of the system and dictate the Ministry of education what it should to do without involving the academic community, students and national general public.

A great amount of numerical values and graphs that are compared with international data, which are provided in their articles, give appearance of profound scientific elaboration of the problem and well-founded reasons for the suggested solutions. Any doubts are rejected by "spook stories" like: "This approach can be an important base for improvement through modeling a new type of the education system suitable for the new economy and public requirements, unless we want to go back to the twentieth century" [2, p. 58].

Lately the authorities have been trying simultaneously to clean the Augean stables that they made in the 90-s and form a new education system that should match the innovative economy [17, 21]. A new structure of the Russian higher education system is being established. Federal and national research universities have been founded, a number of "anchor" universities are expected to start functioning in the regions. The total number of the universities is being reduced by joining "ineffective" universities to larger ones or by merging two or more universities.

The criteria for being "ineffective" are at least disappointing. Experts analyzed results and consequences of different university mergers, which are available in [22–25]. It is possible to agree with the authors that "the consolidation of universities does not solve any problems, but it provides the opportunities to solve them" [23, p. 18], however, a big number of terms and conditions should be complied with. It should be added that consolidation of universities (as well as any other organization) leads to some other consequences that are rarely mentioned: managers whose status declines due to the consolidation become less initiative; the power distance grows; the power is centralized with bureaucracy increasing manifolds; the operating activity of large departments becomes more complicated; personal contacts reduce while the number of management levels increases. It results in worse communication not only between top and mid management but also between students and faculty due to a big number of teaching staff at a department.

"Administrative actions without profound systemic changes cannot overcome the crisis in the higher education system and result in growing additional "layer" of adulteration and imitation. It is an imitation of reforms and an imitation of development management: "managers pretend to manage modernization, faculty pretend to modernize educational and research processes, etc." Various "trendy" innovations are being introduced, such as a rating system, quality management, etc. They often lead to new regulations, reporting formats, etc., and do not really influence the quality of learning outcomes and training process" [19, p. 19].

Unfortunately, as Zh. Toshchenko, a corresponding member of the Russian Academy of Sciences, clearly proves [26], the imitation and adulteration do not limit to the education system, they penetrate the whole system of the state organizations from top to bottom.

Most of the low values of the indicators that are used to assess a university as "inefficient" and "degrading" are really conditioned by the economy crisis, economical policy, and specific geographical positions of the universities. There are a number of reasons for the indicators declining and they cannot be influenced by the universities. Each of 52 indicators and those 10 that are offered to be added [15] should be carefully considered and studied in terms of their benefits for the country. It should be kept in mind that they are proxy indicators, and their functional relation with the declared goals of higher education is not proved. However, it does not need to be proved that

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they distract universities and faculties from the real educational goals to the "indicator-focused" activities. Some representatives of the academic community consider it to be the basic goal of certain reformers.

Some authors [23] even try to explain the difficulties in the reform implementation by the fact "that "mature" faculty negatively react to any changes". Thus, it is "mature faculty" who are guilty in the situation, but not the "mature" reformers who conduct "immature" experiments all over the vast country.

It is undeniable that there are a lot of inefficient universities (in terms of training quality) among those established in the 90-s. They were founded to meet the demand for diplomas rather than for education, which was characteristic of the "education boom of 2000-2005" mentioned by L.M. Filatov [27, p. 70, 72]. Herewith, really mature faculty are not against changes whatsoever, but against those that imitate active management work and come into conflict with the country's interests directly or indirectly [14, 25].

It is noteworthy that a systemic analysis of university's goals made the authors [25] come to conclusion that two sub-objectives of the international rating are directly contrary to the super-goals of the country. This conflict might be more obvious if we took into account such goals of universities as raising patriot-citizens, general increase in cultural level of society, etc. Although the mathematical operation in the article is incorrect, the suggested method can be successfully applied to assess the ways of university development.

Competition vs cooperation

The basic principles of the state policy and legal regulation in the education system are set out in article 3 of the Federal law "About education in the Russian Federation" [28]. Generally, they comply with the long-term goals of the national policy. It is only necessary to start implementing them.

However, paragraph 11 of article 3 leaves perplexed. It says about "unacceptability of elimination or restriction of competition in education". This paragraph may have been promoted by "marketers", as they consider the marker to be an absolute progress driver. For example, the expression "the higher education market" is used 14 times in the article by L.M. Filatova, a staff member of Higher School of Economics (HSE) [27]. However, the education system in general and higher education in particular is value-based and cannot be only profit-focused. Thus, the market elements suitable for international level cannot define the structure of Russian higher education system. Even at the international level the competition in education system should not be profit-focused but promote the country's interests. For example, German higher education is free not only for German citizens but also for students from other countries. The Goethe Institute, which promotes the German language in the world, is 2/3 funded by the German Federal Foreign Office.

It is supposed that competition can ensure education system development, increase training quality, faculty and university efficiency. In fact, the competition fails to drive even the real economy, which is proved by the graphs of GDP growth and of wellbeing of the society that have been had different directions since the era of "reaganomics" started. Stimulated competition in universities leads to moral degradation. "Leveling of academic recognition and violation of meritocratic principles force the most talented people out of the education system by adding more values to non-academic features – obsequence, protectionism, clannishness, and, as a result, lack of professionalism. High concentration of non-academic managers in university destroys the education system and undermines its authority in the society" [14, p. 33–34]. It ensures promotion of people having low moral values, which inevitably influences students' moral character. The process can lead to severe irreversible damage for the whole Russian society.

The danger of competition overestimation even in the market conditions is clearly presented in "Factor 4". The authors claim that competition is a war; the political damage of it could be coped with if we mean only abstract capital. "But people, companies, and nations are inevitably influenced by the billirgent mentality, which results in international tensions and latent danger of cold war" [29, p. 310].

To increase faculty efficiency in universities it is reasonable to develop cooperation at all levels. As for competitiveness, it can be ensured by natural vanity and aspiration for personal fulfillment of a person (on condition it is their calling). Even in real economy there are successful examples of transition from "I" to "We", if the business is properly organized and motivated. It has led to the increase in work efficiency and cost reduction. Such approach is supposed to be more effective in the education system than competition stimulation.

Conclusions: to choose priorities and start acting

Reformation of any system is generally conditioned by the necessity to save and adopt the system to external and internal changes and developments. The question is how intensive and massive these reforms should be and in whose interests should they be carried out. This issue is to be discussed and must be first of all solved in the interests of multinational people of Russia (namely for Russia, not for humanity or Europe; namely for people, not only for voters, authorities, or a globally minded person). This thesis cannot be scientifically proved or grounded. It is a matter of belief, but we can presume that such base is agreeable for the vast majority of Russians.

It is of vital importance to involve enduring intellectual resources that are still persevered in the higher school and the Russian Academy of Science, as well as general public. Otherwise, if the reforms are implemented in HSE-style with belief in market omnipotence, it can result in something described by Chernomyrdin V.: "we wanted to do our best, but we've got what we usually have".

The authors of the foresight research 2030 fairly state that "Specific character and scope of challenges facing the higher school modernization do not allow implementing the reforms only by means of the state authority or university's administrations. It is necessary to unite efforts and coordinate activities of different groups, teams, and projects who feel personal responsibility for transition to the future, for creating new reality that differs from the real one. We can claim that it is necessary to form a coalition of development, that would involve different parties, whose efforts will bring the future" [19, p. 24].

The following steps seem reasonable to be done on this way:

1. To organize all Russian debate on the crisis of higher education:

a. Television broadcasts with fair assessment of current situation from the Minister of Education and Science, the First Deputy Chairman of the Russian State Duma Committee on education, representatives of the Public Chamber, the Employers' Confederation, representatives of employers in the defense industry, and heads of regional level of authority (two or three governors);

b. The reporters should give reasonable review on what measures are being taken, what is planned to be done to improve the situation;

c. It is also necessary to describe the technology of the reform implementation, since it influences personal trajectories of hundred thousand of faculty and millions of students;

d. It is necessary to organize public debate of the issue, similar to those organized by the President of the RF with the results published in mass media.

2. To set requirements not only for professional skills but also to moral values and quality of faculty members.

3. To dismiss the faculty members and other university staff who do not meet professional and, what is more important, moral requirements.

Keeping in mind the "purges" in the Communist party in the Soviet period, we can predict the problem that may arise when this step is implemented. It can be expressed like "who are the judges?" However, this step has to be made if we want to save the country. The Supreme Certification Commission (VAK) has started doing it in a certain way, but from top to bottom, though it should be done from bottom to the top. Anyway, the healthy part of the university faculty is expected still to be capable of taking this decision. It is necessary to learn again how to speak the truth and listen to it, no matter how hard it might be.

4. This step should be followed by the activities to increase the work efficiency of faculty and scientists by reducing bureaucratic procedures and the corresponding staff.

The ways are well known and tested in developed countries: to reduce regulation by applying framework requirements, to delegate powers with corresponding distribution of responsibilities, to use principle of trust (after careful staff selection), to change total control by selective one (scheduled or case-by-case), etc. [30].

There are a lot of ways to increase work efficiency of the faculty, but they need personal initiative and thus, inner motivation. Currently, too many staff involved in the higher education system are demotivated and feel inner resignation.

When interviewed for the journal “Upravleniye biznesom” (Business management), a famous Russian scientist, Doctor of technical sciences, professor of Saint Petersburg ITMO university, T. Paltashev answered the question “what should be done for Russia to reach the modern level of economy?” as follows: “We should start with a moral system, all other things will be done in the regular course of work by mutual efforts of the whole nation. A demoralized army cannot fight; it is just a gang of bandits. A demoralized society is in a state of paralysis, and cannot develop. If there is a moral system in the country, the technologies will soon appear. There are a lot of ways and methods to recover and maintain the moral system of the country. There are historical examples of armies and countries being driven out of “moral coma”. Psychology of human behavior has not changed for thousands of years, thus, these methods and ways are still applicable” [31].

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REFERENCES

1. Romanov E.V. Neeffektivnye vuzy: mif i real'nost' [Ineffective university: Myth and reality]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2012, no. 6, pp. 70–76.
2. Kuzminov Ya. I., Semenov D.S., Frumin I.D. Struktura vuzovskoi seti: ot sovetskogo k rossiiskomu «master-planu» [University network structure: From the Soviet to the Russian “Master Plan”]. Voprosy obrazovaniya [Educational Studies], 2013, no. 4, pp. 8–69.
3. Sandakov D.B. Kak razvalit' sistemu obrazovaniya: diversionnaya programma [How to destroy the system of education: a diversionary program], available at: http://obrazovanie.by/sandakov/kak-razvalit-obrazovanie.html (accessed 16.12.2016).
4. Dulzon A.A., Vasil'eva O.M. O reformirovanii sistemy vysshego obrazovaniya Rossii [Reforming of the Russian higher education system]. Kachestvo obrazovaniya: tekhnologii, ekonomika, zakonodatel'stvo [Education quality: Technologies, economics, and law: Proceedings of the IX Interregional Scientific Methodological Conference], Tomsk, TUSUR, 2007, pp. 6–11.
5. Aurov O.V. Reforma vysshego obrazovaniya: vzglyad iz Moskvy [Reform of higher education: A view from Moscow]. Svobodnaya mysl [Free Thought], 2008, no. 2, pp. 111–124.
6. Zolotukhina-Abolina E., Zolotukhin V. Bol'shaya imitatsiya. Obrazovanie i nauka v sovremennoi Rossii [Big Imitation. Education and science in modern Russia]. Svobodnaya mysl' [Free Thought], 2008, no. 2, pp. 87–94.
7. Fomin D. Vysshaya shkola: poisk rastrachennogo smysla [Higher school: the search for the squandered meaning]. Svobodnaya mysl' [Free Thought], 2008, № 2, pp. 95-110; no. 3, pp. 81–94.
8. Prigozhin I., Stengers I. Poryadok iz khaosa: novyi dialog cheloveka s prirodoi [Order out of chaos: Man's new dialogue with nature], Moscow, Progress, 1986, 432 p.
9. Korenblit S.E. Otkrytoe pis'mo Prezidentu Rossiiskoi Federatsii V. V. Putinu ot professora Irkutskogo gosuniversiteta S.E. Korenblita [The open letter to the President of Russia Vladimir V. Putin from professor of Irkutsk state university S. E. Korenblit], available at: http://newsbabr.com/?IDE=144595 (accessed 24.06.2016).
10. Gus'kova N.D., Erastova A.V. Tsennosti kak element sistemy organizatsionnoi kul'tury universiteta [Values as an element in the system of the university organizational culture]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2015, no. 4, pp. 67–75.
11. Bakshtanovskii V. I., Sogomonov Yu.V. Oikumena prikladnoi etiki: strategiya novogo osvoeniya. Prikladnaya etika: «KPD praktichnosti» [Oecumene of Applied Ethics: A Strategy for the new development. Applied ethics: “Efficiency practicality”]. Vedomosti [Statements of applied ethics], Tyumen, Res. Inst. Appl. Ethics, 2008, iss. 32, spec., pp.29–58.
12. Bakshtanovskii V.I., Bogdanova M.V. Eticheski polnotsennyi professionalizm: individual'nyi dolg ili institutsional'naya podderzhka? [Ethical full professionalism: is it a personal debt or institutional support?]. Vedomosti [Statements of applied ethics], Tyumen, Res. Inst. Appl. Ethics, 2011, iss. 38 – pp. 119–136.
13. Astafeva M.P., Zyateva O. A., Peshkova I.V., Pitukhin E.A. Analiz pokazatelei effektivnosti deyatel'nosti rossiiskikh vuzov [Russian universities in terms of performance indicators]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2015, no. 4, pp. 4–18.
14. Dadaeva T.M., Fadeeva I.M. Reforma vysshei shkoly: paradoksy i tupiki institutsional'nykh izmenenii [Reform of the higher school: Paradoxes and institutional changes stubs]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2014, no. 4-5, pp. 28–35.
15. Melikyan A.V. Pokazateli monitoringa sistemy vysshego obrazovaniya v Rossii i za rubezhom [Performance criteria in higher education monitoring systems in Russia and abroad]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2014, no. 3, pp. 58–66.
16. Lyubimov L. Reforma obrazovaniya: blagie namereniya, obreteniya, poteri [Education reform: good intentions, acquisitions and losses]. Vysshee obrazovanie v Rossii [Higher Education in Russia], 2004, no. 12, pp. 8–24.
17. Karelina I.G., Sobolev A. B., Sorokin S. O. Monitoring deyatel'nosti obrazovatel'nykh organizatsii – initsiativa sistemnykh izmenenii v vysshem obrazovanii [Monitoring the activities of educational institutions – The initiative of the system changes in higher education]. Vysshee obrazovanie segodnya [Higher Education Today], 2015, № 6, pp. 37–46; no.7, pp. 55–61.
18. Strategiya–2020: Novaya model' rosta – novaya sotsial'naya politika [Strategy 2020 – New growth model – New social policy], available at: http://docslide.net/documents/-2020-2012.html (accessed 27.06.2016).

19. Efimov V.S., Lapteva A.V. Budushchee vysshei shkoly v Rossii: ekspertnyi vzglyad: forsait-issledovanie – 2030: analiticheskii doklad [The future of the higher school in Russia: An expert point of view: Foresight research – 2030], Krasnoyarsk, SFU, 2012, 182 P., available at: http://foresight.sfu-kras.ru/sites/foresight.sfu-kras.ru/files/_Doklad_Vysshaya_shkola_-_2030_ekspertnyy_vzglyad_2012_0.pdf (accessed 27.06.2016).
20. Gore Al. Angriff auf die Vernunft, Muenchen, Riemann Verl., 2007, 395 P.
21. Gosudarstvennaya programma RF «Razvitie obrazovaniya» na 2013–2020 gody [Russian Federation State Programme "Development of education" for 2013–2020], available at: https://cdnimg.rg.ru/pril/95/79/95/295.pdf (accessed 27.06.2016).
22. Belyakov S.A., Fedotov A.V., Figurin A.V. Protsessy ob"edineniya v sisteme vysshego obrazovaniya: problemy i vozmozhnosti [Integration processes in higher education: Challenges and opportunities]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2013, no. 6, pp. 8–18.
23. Lisyutkin M.A., Froumin I.D. Kak degradiruyut universitety? K postanovke problemy [How universities degrade? Towards the problem statement]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2014, no. 4-5, pp. 12–20.
24. Klyuev A.K. Organizatsionnoe razvitie vuzov: optimizatsiya praktik [University organizational development: approaches to practice optimization]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2015, no. 6, pp. 57–68.
25. Klyuev Ju.B., Sandler D.G. Analiz strategicheskikh tselei razvitiya vuza [Analysis of university's strategic objectives]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2014, no. 1, pp. 6–17.
26. Toshchenko Zh.T. Novye liki deyatel'nosti: imitatsiya [New images of activity: Imitation]. Sotsiologicheskie issledovaniya [Sociological Studies (Socis)], 2012, no. 12, pp. 23–36.
27. Filatova L.M. Resursy vysshego obrazovaniya: kurs na sokhranenie priema studentov [Higher education resources: Sustaining the students enrollment]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2014, no. 4-5, pp. 67–76.
28. Ob obrazovanii v Rossiiskoi Federatsii [Federal law "On Education in the Russian Federation", no. 273-FL, adopted on 29 Dec. 2012 (last revised 15 July 2016), available from "Kodeks" (accessed 15.07.2016).
29. Weizsaecker Ernst Ulrich von, Amory B. Lovins L., Hunter Lovins. Faktor Vier: Doppelter Wohlstand – halbierter Verbrauch. Der neue Bericht an den Club of Rome, Muenchen, Droemer Knaur, 1997, 352 P.
30. Dulzon A.A. Puti povysheniya rezul'tativnosti truda personala vuza [University staff: The ways of increasing the effectiveness]. Universitetskoe upravlenie: praktika i analiz [Journal University Management: Practice and Analysis], 2013, no. 2, pp. 27–33.
31. Paltashev T.V Rossii nado s moral'yu razobrat'sya, a vse ostal'noe budet sdelano v rabochem poryadke [In Russia it is necessary to deal with morality, and everything else will be done on a routine basis], available at: http://www.rusnor.org/pubs/interviews/8041.htm (accessed 09.03.2015).

UDC 378

Engineering Education and Training of Young Engineers: Practice and Urgent Issues

Ural Federal University named after the first President of Russia B.N. Yeltsin
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The paper studies the role of education system in preparing engineering staff through developing new approaches to designing education programmes and new educational technologies. The conclusions are based on a survey conducted at big Ural industrial enterprises and multi-year engineering student monitoring.

Key words: engineering education, professional pathways, prestige of an engineer, behavioral competence.

Nowadays, the Russian Federation faces a number of engineering and technical challenges. There is a change in the package of basic technologies that make the foundation of modern industrial production and economy in general. The new package of global industry technologies including alternative energy, mobile technologies, smartgrid, and etc. will have been completely developed by 2025. Engineers will obtain the leading role in the new economy. It makes it necessary to train a new generation of engineers who would be able to design engineering systems based on the new technology package. The resources of the Soviet engineering staff have been practically exhausted [1]. Although the annual number of engineering graduates reached 200 thousand by 2000-2010's in Russia, there was a constant demand for engineering staff. According to "Expert RA", in 2014, Russian requirements for engineers were 29% [2]. In this relation, the results of the research made in Sverdlovskaya Oblast, which is of ten areas with highly concentrated industries generating 45% of all Russian industrial production, are also characteristic. In 2013-2014, only 70% of engineering positions in the region was staffed, the average age of the personnel being 53 years old [3].

One of the basic institutional factors that ensure sustainable supply of highly qualified staff is the system of engineering (vocational) education. Scientific, education and industrial experts actively discuss the issues of STEM specialist training, and engineering training in Russia. According to Association for Engineering Education of Russia (AEER) experts, 80% of them representing education society, the quality of modern engineering training is evaluated to be satisfactory by 61.5% of the experts, good – 11.5%, and low – 23.1%. However, more than half of these experts consider the engineering in Russia to be unsatisfactory (systemic crisis, critical condition) [4]. In other words, "the engineers are trained well, but they work badly for reasons out of their control" [5, p. 18-24].

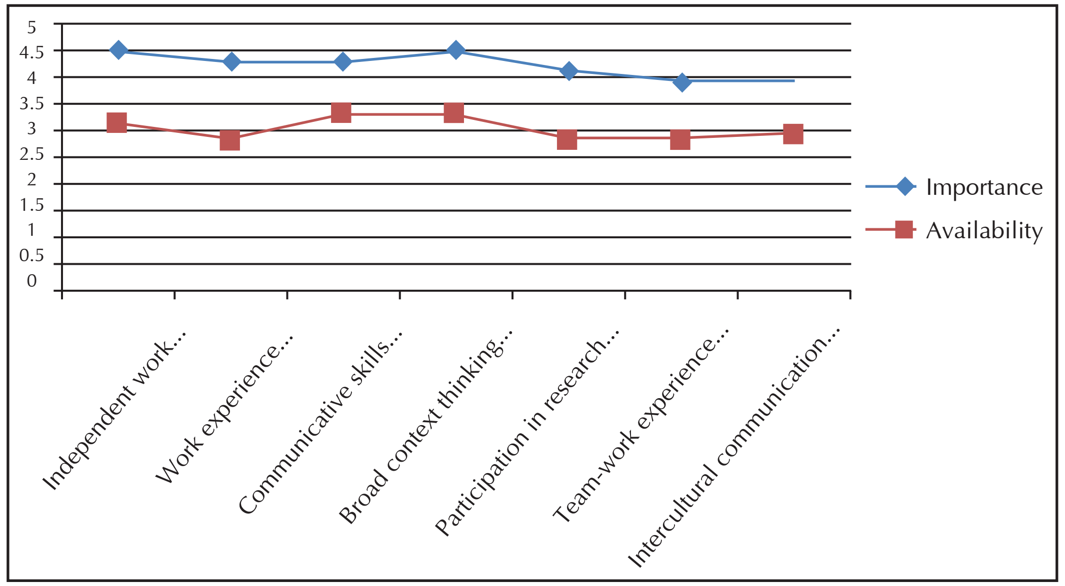
Our research showed similar results [6, p. 276-296]. Virtually all the groups within the educational process (undergraduates, post-graduates, and engineering teachers) positively assess the quality and content of education, and training methods. However, there is still a gap between the required level of graduates' competencies and the real one. A research group conducted a survey among the engineers of the leading regional enterprises (N=240) to evaluate the importance and actual development of soft skills among the engineering graduates in Sverdlovskaya Oblast. The list of competencies was formed similar to the learning outcomes that were used in the international project to study the possibility to apply international assessment of higher education learning outcomes for students studying in diverse language, cultural and infrastructural educational environments (AHELO (Assessment of Higher Education Learning Outcomes), 2008-2012).

Experts claim that the engineering graduates demonstrate competencies at a much lower level than the expected one. First of all, they mean the competencies that are the most important for employers, such as "the ability to accomplish work independently" (to choose research problem and methods). The skill is developed 1.5 times lower than the expected level. Two competencies: "practical work experience" (the gap is 1.5 times), and "communicative skills" (the gap is 1.4 times) take the second place in the importance rank of the employers. The third rank position is taken by "broad context thinking" (complex understanding of their industrial sector, understanding economical context of its functioning). The contemporary graduates are expected to have this competency developed 1.4 times higher than it really is (fig. 1).

The employers are less interested in graduates who have participated in research projects, though the gap between the importance and availability is quite significant (1.4 times). The last place in the rank is placed by "intercultural communication" with the gap of 1.3 times. Generally, according to the survey, no competency has the same values for "importance" and "availability".

While evaluating the educational practices in modern engineering training, the research group was based on the assumption, accepted by the AEER experts, that the engineering education quality is conditioned by the quality of engineering training [4]. While transforming the mass engineering training into the two-level education system, the core of the bachelor's degree level has not been fully understood. In fact, most of the bachelor's degree programmes are based on the principle "5 in 4", that is a list of subjects typical for a five-year course is only adopted for four years, having the same sector-specific curriculum typical for the former training system. A major drawback of such model is conceptual ambiguity of the bachelor's

Fig.1. Employers' assessment of graduates' soft skills and their importance for the employers



degree both in academic and productive spheres. Graduates with a Bachelor's degree are compared either with vocational college graduates, or with engineers graduating from traditional specialist degree programmes.

This issue can be clarified by the national system of competencies and qualifications, which is being developed in Russia. According to the adopted qualification structure, the Bachelor's degree takes the sixth level, which is higher than the fifth one - secondary vocational education (SVE), but lower than the seventh, which is specialist and Master's degrees. It is reflected in the criteria related to qualification levels. For example, the criterion "authority and responsibility" of the fifth level implies "solution of practical tasks", the sixth level – "defining work objectives for themselves or/and for subordinates", while the seventh level means the ability "to choose strategy, to manage activity including innovative one at the level of large departments. This function distribution is taken into account while developing professional standards [7].

Thus, the new education level has started to be accepted by the production sector. There are positive examples of implementing the level approach, different Bachelor's degree models are being developed: practice-oriented, research, multidisciplinary ones (Liberal Arts). Unfortunately, the examples of successful implementation of the level education system are not so widely spread. However, practice-oriented bachelor's degree programmes allow eliminating a social gap between the graduates' need for high social status and labour demand for workers dealing with hi-tech equipment. By 2018, the share of students doing practice-oriented bachelor's degree programme must be not less than 30% of total number of university students [8].

Although the engineering education is very important, it does not automatically provide the industry with new engineering staff. It is more obvious in the current condition: the key factor in the labour market is growing disbalance between the offer of graduates and the labour demand. According to the Russian Federal State Statistics Service (Rosstat), 75% of 1.3 graduates of 2015 have been hired, and only 15% of them are involved in jobs connected with the received training [9, p. 8]. It is obviously caused by surplus "production" of lawyers, managers and economists. The engineering graduates have almost the same difficulties in job search: no more than one third of them "can be provided with the jobs they were trained for" [10].

It is education society that mostly plans the demand for engineering staff nowadays. The current procedure used to determine figures for admissions to technical universities and faculties is based on competitive values of universities' potential used to rank higher education institutions. The assessment of regional labour markets showed that there remains a double structural mismatch between demand and offer in labour market with regard to education level and qualification requirements. The demands of domestic engineering labour market reflect real condition, needs and potentials of the production sector. Low innovative potential of Russian enterprises, poor development of innovative models and practices impede forecasting demands for engineering jobs and qualifications [11]. There are no effective employment models as well as tools to monitor development of further graduates' careers.

The analysis of a long-term monitoring of Ural engineering students allowed identifying the dynamics of their career aspirations and plans[1]. The number of students who chooses their study profile as a future career is reducing (table 1). Such phenomenon as a job out of the degree field has become a commonplace. Students often spontaneously plunge into professional environment (the phenomenon of "working student") that does not relate to the studied

[1]The field stage of the seventh monitoring «Student-2016» has been already finished, however, there final information processing is still in progress.

Table 1. Career aspirations and plans of engineering students (2012-2016, %)*

Professional plans	2007	2009	2012	2016
To use their expertise	41	40	48	**35**
Not to use their expertise	9	10	6	5
To continue their education	8	8	10	**22**
To be involved in research work	3	2	1	1
To start their own business	16	19	11	15
To devote themselves to their homes and families	4	5	2	1
To go abroad to work or study	7	6	6	5
To work as a freelance	–	–	1	1
To live by casual earnings	0	1	0	0
To have internship (further training) at their workplace	–	–	2	2
Career plans are vague and uncertain	16	13	8	**11**
No plans for future	5	**3**	–	3

* The sum is more than 100%, since each interlocutor can give more than one answer

specialty, which leads to the loss of budget resources invested in engineering training [12, p. 145-150].

Every tenth respondent has vague and uncertain career plans. The samples include second- and third-year students doing bachelor's degree (both academic and practical). Experts claim that the demand for graduates with academic Bachelor degree, who are focused on engineering and technological research, is 10% of all the engineering graduates in Russia. No more than 15-20% of all the engineering graduates are in demand in big enterprises that proved their interest by signing contracts for targeted training of engineers with practical bachelor degree (applied Bachelor degree) [13, p. 68].

How reasonable is it to provide Bachelor degree graduates with narrow specialization if there is no proved demand for them in the labour market? The problem can possibly be solved by developing Bachelor degree programmes of "general engineering". The main goal of such programme is to ensure the graduates' ability to easily adjust to any production conditions and be ready to professional retraining and self development. The graduates of such programmes have prospects both in production industry, and academic activity and can choose a variety of Master degree programmes including those that do not relate to engineering.

In comparison with the students studying in universities of Moscow and St. Petersburg, Ural students are not so inclined to go abroad for work or study. Unfortunately, the monitoring did not include the parameters to identify motivation and direction of in-migration. The data of the second national monitoring of graduates' employment held in 2015 show that two out of seven Ural graduates left the region. Those who left have salaries one quarter higher than the salaries of those who stayed (126%). Engineering graduates (heat power engineering, mechanic engineering, and applied geology) who left for other regions are paid one third or quarter as higher as those who stayed [14]. The exception is graduates of some special engineering programmes (technique and technology of surface transport) as well as graduates of some affiliated branches of universities are paid higher than those who left the region. Professional competencies of such students are much more adjusted to the needs of the regional engineering labour market.

While analyzing prospects and problems of modern engineering, some inconsistencies in its development are revealed. The status of engineering activity has an apparent paradox: there is a growing qualitative and quantitative demand for elite engineering staff, which is mostly conditioned by the necessity to implement innovative developments of the country and the region, rather than to maintain the current techno sphere. However, engineering jobs are not still valued high. Another challenge is to combine production discipline, engineering project and creativity, and innovative engineering activity, which is so highly demanded nowadays.

One more set of inconsistencies in engineering development is caused by changing character of engineering activity, and formation of new moral dilemmas. Ethical and moral responsibility of modern engineer can enter into a conflict with corporative interests.

Problems and challenges of the modern engineering make new requirements for the system of engineering training. They reveal inner inconsistencies of the system, aging and out-of-date content of education programmes, which are not practice-oriented enough and can hardly be matched with international standards of engineering training, as well as teaching staff qualification that does not meet modern requirements. There are a lot of "sensitive points" that exist out of professional education system, such as unemployment, quite low social status of engineering positions, which leads to low motivation of school leavers to choose engineering programmes. There is no doubt, the problems mentioned above have a great impact on professional identity of the engineering graduates, who are often called "embryos of engineers" [15, p. 40-43]. In this regard, the role and potential of the educational environment should be studied in terms of building ethical, moral, and professional values of the new engineering generation, since it is engineering that will become a key activity of the post-industrial society, and determine innovative potential and further development.

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REFERENCES

1. Klimov A. Pozovite inzhenera [Call for an engineer]. Rossiyiskaya gazeta [Russian newspaper], 2014, no. 6440, 29.07. (In Russ.)
2. Savosin A. Razvitie inzhenernogo obrazovaniya i tekhnicheskoy podgotovki v Rossii [Elektronnyy resurs] [Development of engineering education and technical training in Russia] presentation. MyShared.ru, 2014. URL: http://www.myshared.ru/slide/771583, free/ Title from the screen (Accessed 03.09.2016).
3. Kompleksnaya programma «Ural'skaya inzhenernaya shkola» na 2015–2034 gody [Elektronnyy resurs]: k Ukazu Gubernatora Sverdl. obl. ot 6 okt. 2014 goda N 453-UG [Complex programme "Ural engineering school 2015-2034 years: to the decree of Governor of Sverdlovskaya oblast no/ 453-UG 6.10.2014]. Kodeks: elektron. fond pravovoy i normativ.-tekhn. dokumentatsii [Codes: electronic bank of regulatory documents], St.Petersburg, ZAO Kodeks, 2017. URL: http://docs.cntd.ru/document/422448790, free. Title from the screen (Accessed 12.09.2016).
4. Kachestvo inzhenernogo obrazovaniya v Rossii [Elektronnyi resurs]: materialy ekspert. seminara: prezentatsiya [Quality of Russian engineering education: materials of experts seminar]. Obshcheros. obshchestv. org. Assots. inzh. obrazovaniya Rossii [AEER], Tomsk, 2014, – 20 P. URL: http://aeer.ru/files/ES_1.pdf, free. Title from the screen (Accessed 13.09.2016).
5. Ogorodova L.M. Kress V.M. Pokholkov Yu.P. Inzhenernoe obrazovanie i inzhenernoe delo v Rossii: problemy i resheniya [Engineering education and engineering in Russia: problems and solutions]. Inzhenernoe obrazovanie [Engineering education], 2012, no11, pp. 18–24. (In Russ. abstr. in Engl.).
6. Vosproizvodstvo inzhenernykh kadrov: vyzovy novogo vremeni [Training of engineering staff: challenges of new time]. In Bannikova L. N.(ed.), Ekaterinburg: Publ. Ural University, 2015, – p. 364.
7. Ob utverzhdenii urovnei kvalifikatsii v tselyakh razrabotki proektov professional'nykh standartov [About the approval of the qualification levels in order to develop projects of professional standards][Elektronnyi resurs]: prikaz Min-va truda i sots. zashchity Ros. Federatsii ot 12 apr. 2013 g. № 148n. GARANT.ru: inform.-pravovoi portal. Moscow: Garant-Servis, 2016. – URL: http://base.garant.ru/70366852, free. Title from the screen (Accessed 11.09.2016).
8. Razvitie obrazovaniya na 2013–2020 gody [Education development for 2013-2020] [Elektronnyi resurs]: gos. programma Ros. Federatsii: utv. postanovleniem Pravitel'stva Ros. Federatsii ot 15 apr. 2014 g. № 295 [state programme of the Russian Federation approved by the Federal government 15.04.2014, No. 295]. Moscow, 2015, – p.146. URL: https://cdnimg.rg.ru/pril/95/79/95/295.pdf, free. Title from the screen. (Accessed 10.09.2016).
9. Karlina E. Poluchil diplom. A chto potom? [You have got a degree? What then?]. Soyuz. veche. 2016, no. 25.
10. Gorbatova A. Kak sostykovat' spros i predlozhenie inzhenernykh kadrov [How to match demand and offer of engineering staff] [Elektronnyi resurs]. Nauka i tekhnologii Rossii [Science and technologies of Russia]. STRF.RU: internet-publ. 17.03.2011. URL: http://www.nanonewsnet.ru/articles/2011/kak-sostykovat-spros-predlozhenie-inzhenernykh-kadrov, free. Title from the screen. (Accessed: 10.09.2016).
11. Otsenka sistemy podgotovki inzhenerno-tekhnicheskikh kadrov: materialy kompleks. issled. potrebnostei krupneishikh region. rabotodatelei. [Assessment of engineering training: results of complex study in large regional employers' needs]. Ekaterinburg: Publ. Ural Federal University, 2016, – p. 272. (In Russ.).
12. Student-2012: materialy shestogo etapa sotsiol. monitoringa, dek. 2011 – yanv. 2012. [Student-2012: results of the sixth social monitoring, Dec.2011-Jan.2012]. Ekaterinburg: Publ. Ural Federal University, 2012, – p. 332. (In Russ.).
13. Rebrin O.I. Sholina I.I. Novye modeli inzhenernogo obrazovaniya [New models of engineering education]. Universitetskoe upravlenie: praktika i analiz. [University management: practice and analysis]. 2016, no. 2, – p. 61–71. (In Russ.)
14. Monitoring trudoustroistva vypusknikov [Monitoring of graduates employment][Elektronnyi resurs]. Portal monitoringa vypusknikov, Min-vo obrazovaniya i nauki Ros. Federatsii [Web portal of graduates monitoring, Ministry of education and science of the Russian Federation]. Moscow, 2015–2016. URL: http://vo.graduate.edu.ru/#/?year=2014, free. Title from the screen (Accessed 06.01.2017). (In Russ.)
15. Livshits V.I. Problema lakunarnosti v modernizatsii inzhenernogo obrazovaniya [Lacunarity problem in engineering education modernization]. Akkreditatsiya v obrazovanii [Accreditation in education]. 2011, no. 7, pp. 40–43. (In Russ. abstr.in Engl.).

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UDC 378.14

Social and Professional Adaptation of University Graduates in the Labor Market

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The article deals with the problem of adaptation of graduates of higher education institutions in the labor market in modern conditions. Based on the results of questionnaires and interviews with young specialists and employers, factors that influence the social and professional adaptation of graduates of higher education institutions are revealed. The viability of interaction of outcome-based, contextual, problem-based and personality-oriented approaches in the educational process to prepare a competitive specialist who is able to successfully adapt in the labor market is explored.

Key words: labor market, graduates of higher education institutions, social and professional adaptation, competences, personal qualities, value orientations.

Social and economic transformation, the integration of Russia into global market, the emergence of new values, led to the fact that the labor market began to demand the specialists capable of quickly navigating in the surrounding reality. At the moment, the nomenclature of jobs is changing very rapidly and the demand for highly qualified specialists is constantly growing. At the same time, every employer is interested in obtaining a specialist who requires a minimum period of adaptation to professional activity. It is supposed that students apply to university to graduate it further as highly qualified specialists. However, in the opinion of the majority of employers, graduates of higher education institutions must be trained directly at the workplace. The process of student's adaptation to the specifics of professional activity can take a fairly long period.

Social adaptation is understood as the process of adaptation of a subject: a person, a community to a social environment, involving interaction and a gradual harmonization of the expectations of both parties. When tallking about socio-professional adaptation, we mean the process of adaptation of the individual to the conditions and norms of new professional activity, mastering of production norms of behavior, professional ethics [1, 2, 3]. When entering a job, a young specialist falls into the system of professional and socio-psychological relations within the organization, assimilates norms and values of professional activity, coordinates his individual position with the goals and objectives of an interprise [4].

The role of the education system in this situation is to help the graduate to develop qualities that enable him/her to become a professionally wealthy, competitive, active person, able to adapt to the conditions of professional activity in the shortest possible period of time. Therefore, adaptation as a process and adaptedness, as a personal characteristic, becomes fundamental for a young specialist in the process of his preparation and professional activity.

To analyze the degree of social and professional adaptation of graduates to professional work, a survey of young specialists working at the enterprise for no more than 3 years was conducted. In the first place the main interest of the survey is focused in the primary adaptation of the graduate of the university to professional work. This is the period when appear the most frequent situations associated with the mismatch of ideas and expectations about professional activity with reality, and as a consequence a change in professional activity takes place. Although the status of a "young professional" is not set in the Labor Code, it is valid for 3 years from the date of the employment contract and is not re-assigned. A total of 86 people took part in the survey.

The results of the questionnaire are presented in table 1.

The first questionnaire, proposed to graduates, was drawn up in order to identify their own assessment of how quickly they were able to adapt to the conditions of professional activity, to the profession itself, to the norms and values of the professional team.

According to the analysis of the survey results, the following conclusion can be drawn:

- 70% of the respondents adapted to the standards and values of the professional team, 20% did not have relations in the team, others found it difficult to answer;
- 54% of those who participated in the survey adapted to the conditions of professional activity, 8% found it difficult to answer, the rest answered "did not adapt";
- 48% of the respondents adapted to the specifics of their professional activities, 10% of respondents found it difficult to answer, the rest did not adapt.

Thus, it can be noted that the subjective perception of the adaptation degree by the graduates is at a rather low level. The best results were achieved in adaptation to the team, to the traditions and values that are are shared in the team.

Further, the graduates were asked to answer what factors, in their opinion, can help to go through the adaptation process

Table 1. Self-assessment of the process of social and professional adaptation of graduates

Object of Adaptation (To which the graduates adapted)	Graduates (% of the total number of respondents)
To the conditions of professional activity	
Adapted	53
Difficult to answer	8
Not adapted	38
To the profession	
Adapted	48
Difficult to answer	10
Not adapted	42
To norms, values of the professional team	
Adapted	70
Difficult to answer	10
Not adapted	20

successfully. The list of factors had to be ranked according to importance, by placing the most important factor to the first place. The questionnaire and the results of the survey are presented in table 2.

Factors that have a value of 50% or higher, we will consider as the most significant, the factors of primary importance, the "first priority". Factors noted by 30% to 49% of respondents, as secondary, less significant, "second priority". The factors noted by less than 30% of respondents are considered as the "third priority".

Thus, according to the graduates the most important factors contributing to adaptation in the labor market are "the availability of work experience" and "the availability of professional competencies".

The second group includes such factors as the "availability of certain personal qualities" (49%), the "ranking of the institution that issued the diploma" (38%) and "Links, contacts" (36%). It should be noted that the last two factors are almost equally estimated by graduates. The respondents attribute to insignificant such factors as "absence of family, children","age", "gender".

The hierarchy of adaptation factors generated by the interviewed graduates suggests the "existence of experience in this field of activity" and the "availability of good knowledge" among the primary factors, as well as the "availability of certain personal qualities". Provide with all the necessary factors is precisely the aim of properly organized system of higher education, as well as the desire and aspiration of the student. For example, the "availability of professional competencies" can not be replaced by relatives or acquaintances. You need to acquire all the skills yourself. This means that professional experience and the availability of professional competencies prevail among the qualities required by applicants for employment, as well as "certain personal qualities" will help a young specialist to adapt more quickly to the norms and values of a professional team, and should not be dismissed in a career building.

At the next stage we decided to find out the employers' opinion on the factors that do not allow a young specialist to successfully adapting to the labor market. Employers were asked to note what factors, in their opinion,

Table 2. Factors of socio-professional adaptation (% of interviewed)

Factors of social and professional adaptation	Graduates
1. Availability of work experience in this field	**63**
2. Availability of competencies	**98**
3. Availability of certain personal qualities	**49**
4. Ranking of the institution that issued the diploma	38
5. Links, contacts (help from relatives, friends)	36
6. Lack of family, children	19
7. Age	16
8. Sex	8
9. Other	3

prevent successful adaptation of a young specialist. A total of 103 employers took part in the survey. The results are shown in table 3.

The opinion of employers almost coincides with the opinion of graduates. According to employers lack of work experience and competencies in the first place do not allow a young specialist successfully and quickly adapt to the labor market. Employers also note the poorly formed personal qualities of a young specialist. Most employers believe that young professionals have poor communication skills, organizational skills, that is, the ability to work in a team, responsibility and efficiency.

Based on the results of the conducted research, it is possible to outline the following components of successful adaptation of the graduate in the labor market (fig. 1).

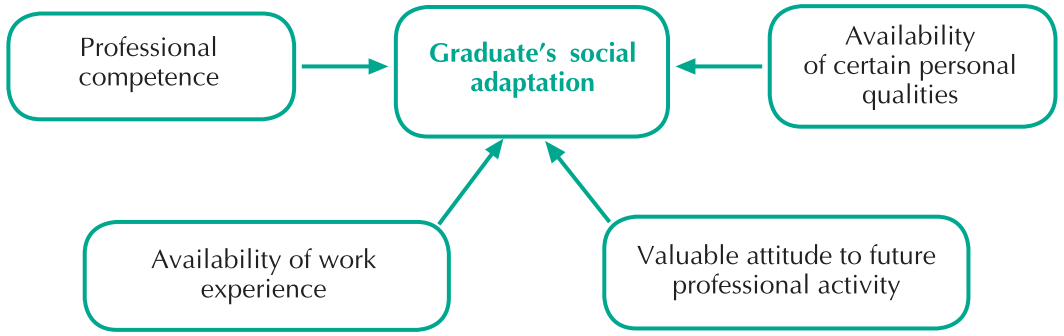
Below we will consider each component in detail.

Many researchers note that the content of training still remains focused on theoretical knowledge, and, mainly, without practical application in real activity [5, 6, 7, etc.]. The need to bring back the system of mandatory internship is declared by the organizers of education [8]. Verbitsky noted that the knowledge, abilities and skills acquired in the learning process should be transformed into means of solving problems in real professional activity [9].

Table 3. Hierarchy of factors that make it difficult to adapt to the labor market of graduates, in the opinion of employers (% of interviewed)

Factors	Employers
1. Lack of experience in this field	70
2. Lack of links, contacts	0,9
3. Lack of competencies	100
4. Lack of certain personal qualities	62
5. Sex	7,9
6. Family, children	23
7. Age	2,9
8. Ranking of the institution that issued the diploma	11,6
9. Other	3,8

Fig. 1. Factors affecting socio-professional adaptation



One of the main requirements of employers to graduates today is the availability of work experience. The solution largely depends on the effectiveness of internship experience. However, in our view, practical training, especially in the period of shortening of theoretical training and increasing the share of independent and practical work at universities, can not be considered in isolation from the theoretical preparation of students. On the contrary, practice is a logical continuation of theoretical training, and theoretical preparation should be the foundation, the basis for solving practical problems. To implement the requirements articulated in the educational standards, both theoretical and practical training are necessary.

Today participation of employers in the process of forming the basic educational programmes of universities becomes an indispensable condition of the educational process. In this regard, the university and the department actively interact with employers in line with their training profile. Student internship is the most traditional way of interaction between universities and enterprises.

As follows from our analysis of existing standards, they only define the types of internships, but do not specify the content of practice, the form of realization, the requirements for the facilities, and so on. In our opinion, the internship should become one of the priority areas in the educational process. The professional growth of students as future competitive specialists directly depends on the effectiveness of the organization, content, forms and methods of professional training of students in framework of their hands-on practice at different stages. Each stage of internship should be the final stage of training on the relevant course and serve as a basis for the student's transition to the next level of training.

The orientation toward solving the practical problems of forming professional competence forces us to reconsider (in the context of the concept of modernization of education) the change in the main components of the internship: its purpose, content, the criteria for the effectiveness of forms and methods of instruction, the student's functions at different stages:

- **The purpose** of the internship in relation to the problem of development of professional competence means that students in the process of hands-on practice have not only to learn the material based on specific activities, but to expand and complicate their individual intellectual resources by means of practical activity.
- **The content** of the internship. The content of the internship should be selected and organized in such a way that students can test all the activities of the future profession with the aim of developing certain competencies that form the basis of professional competence.
- **Criteria for the internship effec-tiveness.** All forms and methods of organizing the process of hands-on practice should be oriented towards the formation and development of professional competencies and personal qualities. As a criterion for assessing the effectiveness of the practice, not only the indicators of competency formation will appear, but also the experience of solving specific practical problems in the sphere of future professional activity.
- **The student functions** within internship. The functions must corres-pond to the real functions of a specialist. Within the internship experience students have to realize the function of designing the course of individual intellectual development as future professionals. Accordingly, such forms of student activities that contribute to the formation of certain competences come on the foreground [10].

The internship should be considered as a logical continuation of the previous theoretical preparation, and should include (along with a standard report) the execution of a project prepared in advance by a student (system of interrelated mini-projects) under the supervision of the teacher responsible for internship, as well as creative tasks to solve specific practical tasks related to the future sphere of professional activity, etc.

With such an organization, internship becomes a link between theoretical preparation and subsequent practical activities of students - the prerequisite for successful social adaptation to future professional activity is the basis for the formation of professional competence.

Competencies are determined by the content of professional activity. Their set is indicated in the standards, as well as in the social demand. To identify the competencies needed by the employer, we analyzed educational standards in the economic field of training. All competencies were systematized into groups. The result was used to design a questionnaire and conduct a survey among employers in order to identify the competencies required by young professionals for practical, professional activities. A total of 46 employers from commercial organizations and government agencies participated in the survey. The list of most significant competencies that contribute to successful adaptation includes: communicative, research, organizational, information competence.

In addition to the availability of certain professional competencies of the university graduate, his social and professional adaptation depends on the availability of certain personal qualities.

Experts in the process of professional activities perform not only professional, but also social roles. In the employment process, adaptation and further career development they constantly interact with representatives of various professional and social communities. Their social and professional success largely depends the way they impress others and efficiency of their communication system. To study the influence of this factor on the adaptation process, we also developed a questionnaire that offers employers to choose from the list of various personal qualities those qualities that will allow young specialists to quickly adapt and engage in professional activities. Based on the questionnaire results we found out that in the employers' opinion such qualities as responsibility, diligence, self-control, the ability to work with information, the ability to defend one's point of view, initiative are necessary for graduates for successful adaptation and further professional career development.

The effectiveness of the social and professional adaptation of the young specialist is also dependent on his valuable attitude to the future career.

The main purpose of higher education is to involve students in the future professional activity. Accordingly, the improvement of the educational process can and should take into account the assimilation of the individual values of their future professional activity. As J. Raven noted the formation of a professional primarily relates to a problem of forming a personality of the future professional, therefore an individual competence growth should be continuously connected to the system of values [11]. In our opinion, this happens because in the process of training not enough attention is paid to the formation of the valuable attitude to their future profession.

If graduates have professionally significant value orientations, it provides conscientious attitude towards chosen profession and desire to be engaged as soon as possible in professional activities.

In this regard, in the training process of future professionals it is necessary to find and implement such approaches in the organization of the educational process, which would provide the conditions for professional adaptation, personal development, the ability to compete effectively and realize their potential, taking into account the labor market needs. As a fundamental approach for the implementation of these requirements, we selected the competence-based approach.

This approach involves active participation of students in the learning process, as opposed to passive assimilation of information. The learning outcomes focus on the development of general cultural and professional competencies. This approach suggests that the educational system does not focus only on providing students a certain amount of knowledge and skills, but on developing a holistic set of key competencies.

However, the formation of professional competence will be effective only if the educational process is close to the real professional activity. Bring the educational process closer to the real professional activity becomes possible by the implementation of the contextual training approach.

Provide an individual with knowledge that will enable him to carry out a successful operation for a long period of time becomes more and more difficult. Recently the main value is not the knowledge, but awareness or understanding about where and how to apply this knowledge. And even more important is the knowledge about how to extract information, to integrate, or create [12, p. 66]. The first, the second and the third are the results of activity, and one of the most important elements of educational activity is to solve problems. Different tasks and problems are an essential component within contextual training approach, since in the problem solving process one can acquire and master modes of operation needed in future career.

In this perspective an active introduction context-oriented tasks and assignments to the learning process becomes vital at university. Students in the process of solving problems and tasks is placed in the activity-position and gets the practice of using the educational information in a simulated professional activities [13]. This further allows to significantly reduce the period of adaptation of the young expert in the enterprise and ensures its natural entry into professional employment. However in a real life, graduates have to deal with all sorts of tasks. There are tasks that can be easily solved following previously studied algorithm, but there can arise problems that require analysis, synthesis, and more.

Tasks and problems have a common nature – a problem situation. An individual involved in this situation becomes aware of the challenge, this enables him to generate new knowledge that will allow him to find a way to resolve this challenge. M.L. Zueva notes that as a rule when solving the problems students use the algorithms that the teacher showed them. However, in practice it can often lead to the fact that graduates are unable to solve the problem with the modified conditions [14].

Thus, for the formation of students' ability to solve problem situations requires problem-based learning. The main aim of this approach – is the development of students' ability for independent work, formation of research skills, and development of cognitive and creative abilities.

In the current context, ability to solve problems is highly valued by employers. The importance of such skills is explained by the fact that employers are interested in employees who are willing to take responsibility and to work independently.

To do this you must be able to identify the problem and offer its solution, this is the key problem-solving skill. Ability to solve problems is an important aspect of quality management - the concept of continuous improvement is based, primarily, on a person's ability to analyze operations, identify problems and find ways to improve. In the process of resolving problem situations a student develop personal qualities such as the ability to work in a team, responsibility, communication, research, and information competence.

Therefore, problem-based learning plays an important role in social and professional adaptation of young specialists in the company. Problem-based learning may also be implemented within internship period.

In addition, problem-based learning, the desire to solve the problem generates interest of students to the subject, and enhances their motivation to study.

Student-centered approach plays an equally important role in the social and professional adaptation of young

specialist. It recognizes the uniqueness of the subjective experience of each student, as an important source of individual life activity, and particularly in learning activity. This recognizes that education does not mean just mastering of certain pedagogical influences by the students, but also a way to meet intended and subjective experience, to ensure its enrichment, transformation, being a "vector" of individual development [15]. Student-centered approach is considered today as a specific pedagogical activity, which creates favorable conditions for students, contributing to the development of their abilities, initiative, independence, self-development [16].

However, each of the considered approaches together with the positive also has negative sides. That is why applying the best components of each approach approaches in interaction can enrich the content of the educational process.

According to the labor market requirements university graduate should be a fully developed personality, and have not only a certain set of competencies, but also necessary personal qualities, to be able to adapt quickly to rapidly changing conditions and solve arising professional problems.

In order to form this kind of graduates with the required competencies, personal qualities, ability to solve problems and value attitudes to future professional activity, ability to adapt quickly to the changing conditions, norms, values and specific professional activity it is necessary to apply a combination of competence, context, problem, and student-centered training.

REFERENCES

1. Vlasyuk, D. Professional and social adaptation of graduate // Vysshee obrazovanie v Rosii (Higher education in Russia) – 2007. – № 9. – pp. 160–162.
2. Vrazhnova, M.N. A system of professional adaptation of students // Vysshee obrazovanie v Rosii (Higher education in Russia). – 2004. – № 9. – pp. 118–124.
3. Zhigadlo A. The quality of training and employment of young specialists: sociological aspect / A. Zhigadlo, V. Puzikov // Vysshee obrazovanie v Rosii (Higher education in Russia). – 2007. – № 10. – pp. 108–112.
4. Ishkova, A.E. Adaptation of youth to the labor market: problems and ways of their solution // Pedagogical science: Past, Present, Future: Proceedings of international scientific conference -Novosibirsk: ESKNE, 2011. – Part 2. – pp. 103–108.
5. Polisadov, S.S. Practice-oriented teaching in high school // Layered training: e-learning and open educational resources: Proceedings of I All-Russian scientific- method. Conference, Tomsk, 20 - 21 March 2014. – Tomsk: Publishing house TPU, 2014. – pp. 349–352.
6. Gabysheva, L.K. Practice-orientation as a guarantee // VII Tyumen innovative oil and gas forum: Proceedings, Tyumen, 21 - 22 September, 2016. – pp. 21-25.
7. Bondarenko, T.N. The role of a practice-oriented approach in the university educational process in the formation and development of Russian industrial and regional markets of services [electronic resource] / T.N. Bondarenko, A.P. Latkin // Modern problems of science and education. – 2012. – № 6. – URL: http://www.science-education.ru/ru/article/view?id=7784 , free. – Tit. from the screen (usage date: 25/11/2016).
8. Yashina, G. The problem of engineering personnel in Russia and its solutions [Electronic resource] // The capital of the country. – 2011 – 30 of March. – URL: http://kapital-rus.ru/articles/article/problema_inzhenernyh_kadrov_v_rossii_i_puti_ee_resheniya, free. – Tit. from the screen (usage date: 02/10/2015).
9. Verbitsky, A.A. Competence approach and the theory of contextual learning / A.A. Verbitsky. – M.: ИЦ ПКПС, 2004. – 84 p.
10. Suzdalova, M. The About problem of professional personnel shortage in mechanical engineering industry and ways of solving [Electronic resource] / M. Suzdalova, E. Politsinskaya, A. Sushko // Procedia – Social and behavioral sciences. – 2015. – Vol. 206. – pp. 394–398. – Tit. screen. – doi: http://dx.doi.org/10.1016/j.sbspro.2015.10.072
11. Raven, John Competence at modern society: identification, development, implementation / J. Raven . – M.: Cognitive-Center, 2002. – 470 p.
12. Bershadsky, M.E. Didactic and psychological foundation of educational technology / M.E. Bershadsky, V.V. Guzeev. – M.: Ped. Poisk, 2003. – 256 p.
13. Politsinsky, E.V. The organization of the training of technical college students using practice-oriented tasks [Electronic resource] / E.V. Politsinsky, L.G. Demenkova // Asian Social Science. – 2015. – Vol. 11, № 1. – pp. 187–192. –Tit. screen. – doi: http://dx.doi.org/10.5539/ass.v11n1p187
14. Zuyeva, M.L. Efficiency of problem-based approach for the formation of the key educational competencies // Yaroslavl Pedagogical Vestnik. – 2007. – № 2. – pp. 36–47.
15. Asmolov, A.G. Psychology of personality. Principles of general psychological analysis/ A.G. Asmolov. – M.: Publishing house of Moscow State University, 1990. – 367 p.
16. Alekseev, N.A. Student-centered learning; Theory and Practice / N.A. Alekseev. – Tyumen: Publishing house TSU, 1996. – 216 p.

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Professional Culture as Basis for Engineering Masters' Professional Activity

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Today, the enhancement of engineering master's competitiveness requires a cultural ground. The article justifies that the formation of a cultural ground is achieved through the development of a professional and project-oriented culture, as well as a scientific and methodological culture of master students within the process of engineering education. Both professional and project-oriented, and scientific and tutorial cultures are presented in the article as important qualities of engineering master students; their structural components are identified taking into account future masters' professional activities. The inability of the existing pedagogical models to solve the identified problem sets a task of developing two basic models: a model providing focused development of a professional and project-oriented culture and a model for the development of a scientific and tutorial culture of engineering master students.

Key words: master student, engineering education, professional culture, model simulation.

Modern practice shows that in order to raise the competitiveness of an engineering master graduate a certain cultural basis of his/her professional activity is needed. Today, professionals in any sphere develop their own professional competences, knowledge, skills, abilities and expertise to assure their own competitiveness based on a sufficient level of a professional culture. Besides, the new concept of Russian education that correlates with the formation of a competitive and developed personality is based on the principle of gaining knowledge, skills and abilities in the context of an integrated panhuman culture [1, 2, 5]. These conditions define the importance and topicality of the problem of developing a professional culture as a foundation for future professional activity of engineering master students [3, 7].

The scientific data analysis has led to a conclusion that the professional culture (in particular the project, scientific and methodological ones as professional characteristics of a master's personality) is a certain way for realization of his/her professional career.

Project-based learning plays an important role in training master students for their professional development [4; 8].Project design is a practical tool for communication [4, 8]. Professional project-based culture of master students is seen by the authors as a comprehensive framework of a person that consists of an integrative system of social, professional and personal characteristics built upon interconnected and interdependent constituents (axiological, cognitive, pragmatic, behavioral), which, in their turn, are formed based on the system of values of professional self-development. This system of values appears as an imperative for the professional competency of engineering master students (Table 1).

Table 1. Structure and contents of professional project-oriented culture of engineering master students

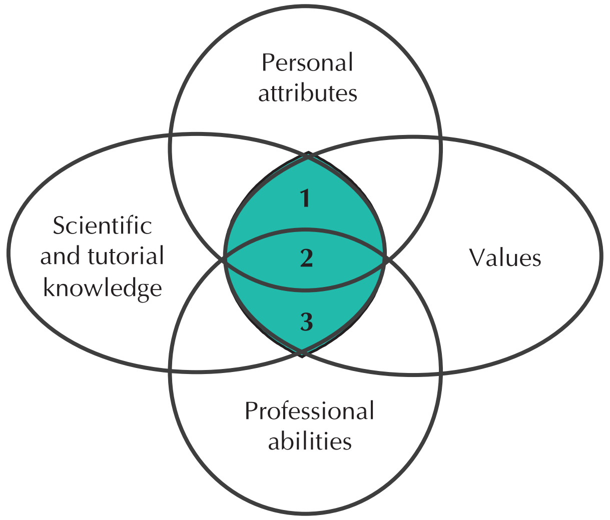
Components	Content
Axiological	1) Understanding the value of human life. 2) Showing tolerance towards communication partners and strive towards mutual understanding. 3) Knowledge of values of professional and project-oriented culture (PPOC) as its basis, fostering the organization of professional activity. 4) Understanding the significance of the PPOC culture for professional development. 5) Intellectual abilities. 6) Politeness, tact, truthfulness, justice.
Cognitive	1) Grasp of a system of knowledge on nature, its laws, mechanisms, humanistic ways of acting and their cultural form; knowledge on rules and norms of research, design and efficiency assessment. 2) Readiness to enhance own knowledge on professional activities, culture and its types, professional and project-oriented culture and its core components. 3) Ability to make contacts with communication partners, to fortify communicative interaction. 4) Showing empathy to communication partners. 5) Attractiveness in communication, ability to make oneself well-disposed and trusted.
Pragmatic	1) Ability to navigate within communicative or etiquette situations. 2) Ability to analyze, plan and execute. 3) Ability to design business communication. 4) Ability to navigate within abnormal situations. 5) Possession of skills on mediaplanning and budget planning. 6) Ability to use kinetic communication tools. 7) Ability to analyze and assess professional activity and its results. 8) Knowledge on technology, means and tools of practical activity and application of a range of tools for solving professional problems.
Behavioral	1) Ability to transform values of professional and project-oriented culture, interpret socially-valuable experience. 2) Existence of an individualized professional style of action, ability to perform creatively. 3) Existence of organizational skills. 4) Ability to behave assertively. 5) Existence of a need for creativity, self-development, self-improvement in a profession, implementation of innovations in a professional area.

Analysis of a number of research works has indicated that master students, who seamlessly combine scientific and pedagogic activities, are capable of representing learning material in a generalized and systematized manner, able to bring together figural and verbal forms of data representation, able to analyze and foresee students' difficulties [5; 9]. The authors are convinced that pedagogic activities of master students are insufficient, if the educational process of these students does not include, to a full extent, such opportunities that are aimed at achieving higher results of educational activity, in particular, results, achieved by scientific and research activities. In other words, the efficiency of master student's pedagogic activity depends, in a way, on the depth of integration of scientific, methodological and innovative activities provided for him/her. The authors' opinion is that the mechanism of such integration is determined by the task-oriented development of scientific and tutorial culture of engineering master students.

The concept of "scientific and tutorial culture of engineering students" is based on the dialectics of the unity of a general (professional culture of a specialist as a whole, as a complicated concept) and a specific (which is determined by the specifics of scientific and tutorial activities of an engineering master student). The structural components of the scientific and tutorial culture of engineering master students are presented on fig. 1.

In theory and on practice professional education of engineering master students has gained vast experience in formation of both professional and project-oriented cultures. However, the problem of development of the professional and project-oriented culture, as well as the scientific and tutorial culture of a future master graduate is still under-researched. Inability to use the existing pedagogic models for solving this problem has set a task for development of two basic models: a model assuring task-oriented development of the professional and project-oriented culture and a model

Fig. 1. Structural components of the scientific and tutorial culture of master students



1-2-3 – scientific and tutorial culture of a master students
1 – professional self-awareness; 2 – creative thinking;
3 – scientific and tutorial skills.

for development of the scientific and tutorial culture of engineering master students.

Methodological landmarks for research of the development process of the professional and project-oriented culture of engineering master students are the key ideas of such approaches as system, activity, cultural, holistic, axiological and professional approaches. The integration of these approaches allows constructing a model for development of the professional and project-oriented culture (PPOC) of engineering master students. This model consists of four interconnected modules: "Motivation and Aims", "Content and Organization", "Process and Methods" and "Assessment and Results" (fig. 2).

Specifics of this model lie at the roots of its professional focus, technological and didactic sequencing, integration of the enlisted modules, interaction between them and strive for achievement of the planned results.

Speaking of the model for development of the scientific and tutorial culture of engineering master students it should be noted that this model, in its turn, is focused on the development of professional self-awareness, creative thinking and scientific and tutorial skills of future masters. The model includes the following key modules: "Theory and Methodology", "Perspectives and Aims", "Content and Concept", "Organization and Operation" and "Integration and Evaluation". A short description of each module is listed below.

In particular, the module "Theory and Methodology" is based on two core components: methodological approaches and psycho-pedagogic theories and concepts. This module integrates ontological understanding of essence and specifics of the realization of scientific and tutorial culture development process. Scientific views on the process of individual's rise towards a certain culture are also determined. This element includes: theory of individual and his/her development through activities; theory of professional and personal development and self-development; concepts of personal and

Fig. 2. Modules of a model for development of the professional and project-oriented culture of engineering master students

Module "Motivation and Aim"

- **Functions**
  - **Motivation**
  - **Task-orientation**
- **Factors**
  - **External factors:** specifics of socio-professional relations, employers' requirements, professional and educational culture of an HEI, status and prestige of the profession within society
  - **Internal factors:** socio-cultural interspace of the profession, its specifics, personal professional experience, specifics of interactions with related field-specific areas
- **Stages of motiva-tional process**
  - **Stage 1.** Formation of a primary motive
  - **Stage 2.** Formation of a specified motive
  - **Stage 3.** Choice of a specified aim and an impulse for action
- **Result**
  - **Result:** strive for acquiring professional and project-oriented culture

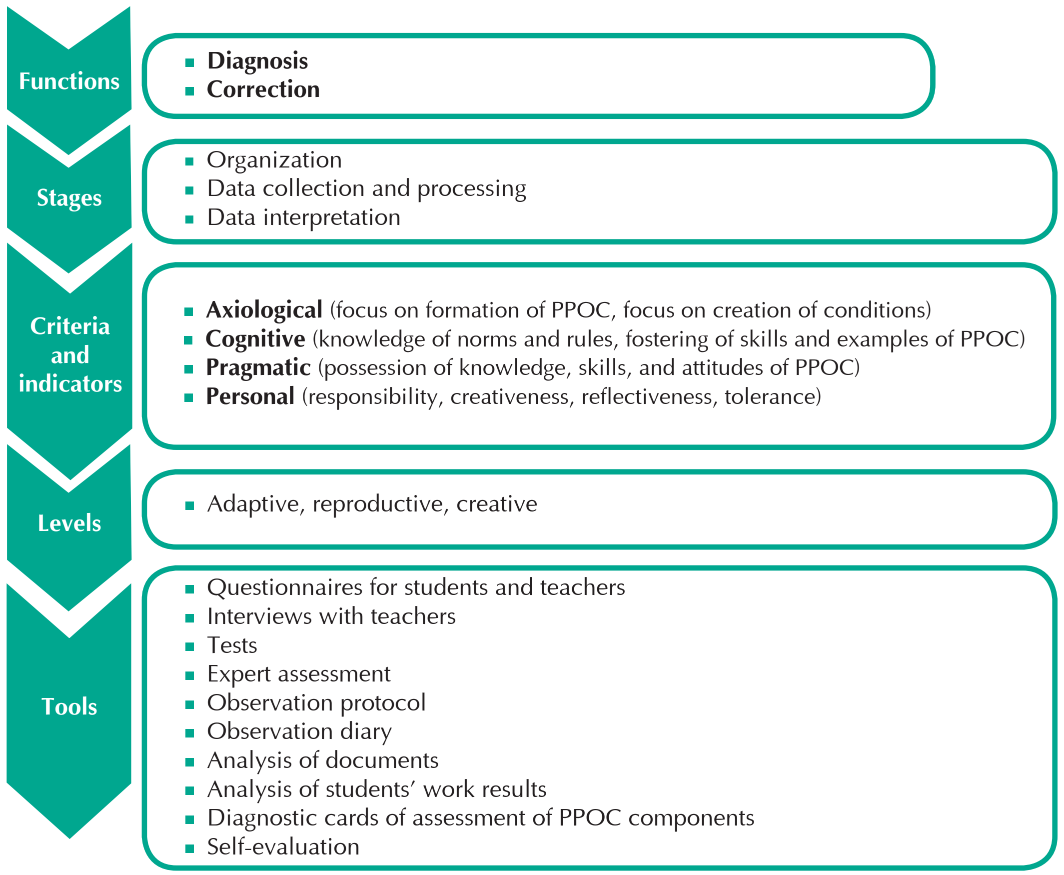
Module "Content and Organization"

- **Functions**
  - **Information**
  - **Organization**
- **Principles**
  - Phasing, cultural conformity, practical focus, interdisciplinary integration, professional orientation, facilitation, reflection
- **Structure of PPOC**
  - Axiological component
  - Cognitive component
  - Pragmatic component
  - Behavioral component
- **Develop-ment program for PPOC**
  - **Section 1:** Informational and theoretical (acquiring the information needed)
  - **Section 2:** Practice-oriented (acquainting with methods, forming particular skills)
  - **Section 3:** Comprehensively reproductive (solving comprehensive tasks)
  - **Section 4:** Project-based and creative (forming skills of PPOC, expanding project activity expertise)
- **Interdis-ciplinary relations**
  - Business communications, basics of integrated communications, imagology, corporate culture, theory of communications and research

Module "Process and Methods"

- **Functions**
  - **Release of information**
  - **Presentation**
- **Teaching methods**
  - Monologue, dialogue, problem-based, project-based, games, workshops, reflective, etc.
- **Forms of work**
  - Binary lectures, lectures – conferences, PR-projects, business games, role and story games, workshops, competitions, project seminars, practicums, image workshops, extracurricular activities, etc.
- **Stages of PPOC**
  - Propaedeutic
  - Organizational and prognostic
  - Procedural and motivational
  - Integrational and remedial
- **Stages of PPOC acquisition**
  - Primary review of material
  - Comprehension of material
  - Acquisition of material
  - Application of knowledge, skills and attitudes gained to practice

Module "Assessment and Results"



professional development in continuous education, etc.

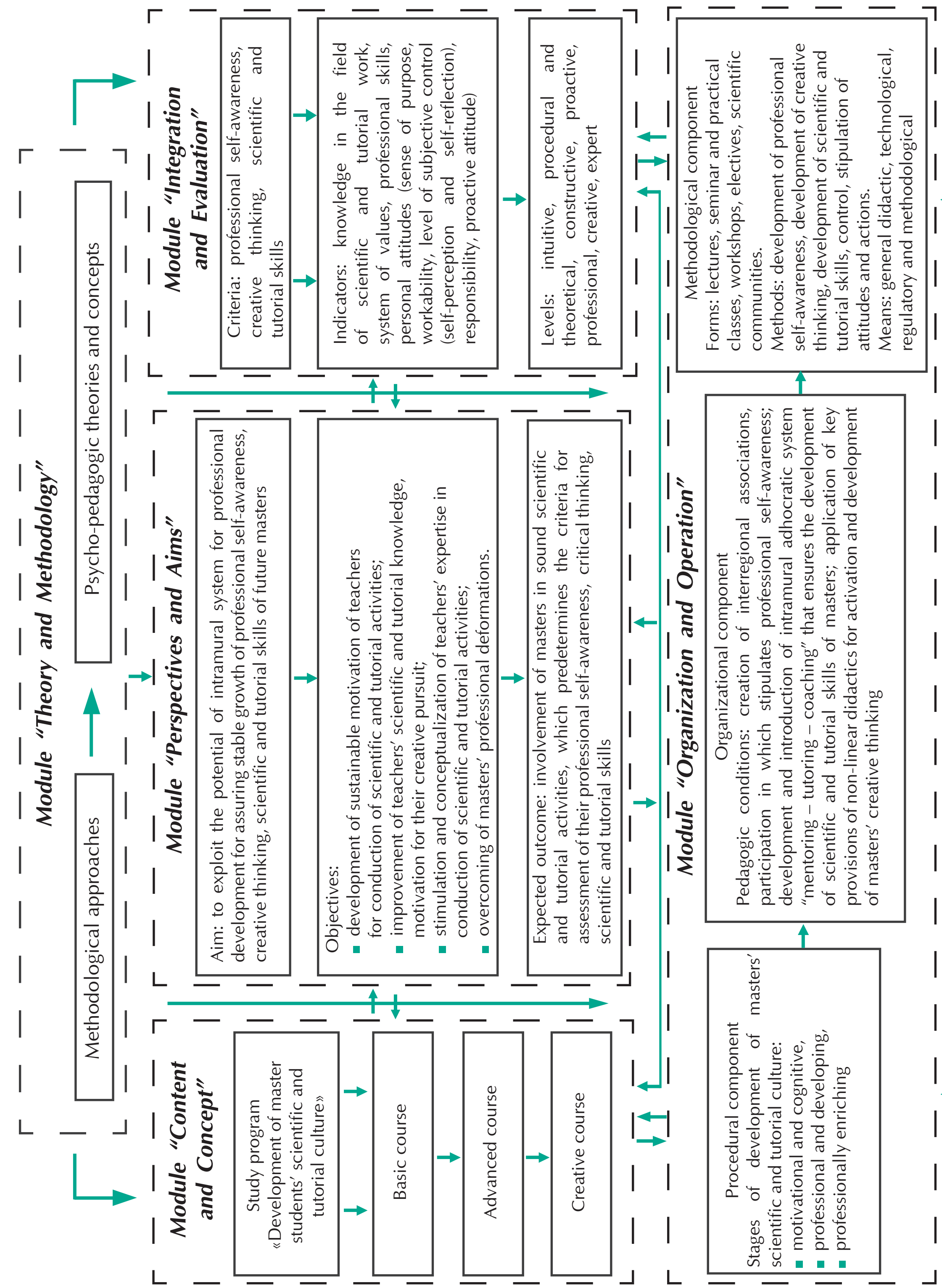
The "Perspectives and Aims" module determines a particular strategy and vector for the development process of the scientific and tutorial culture of engineering master students. As practice shows, it is the aim that determines an object's future state, i.e. the state, to which all object of a particular activity are aimed; whereas the expected outcome is the development of the scientific and tutorial culture of engineering master students.

The module "Content and Concept" reflects the conceptual fulfillment of core Master Degree majors for efficient execution of methodological, innovative and scientific activities. This module represents a vocational study programme, which is aimed at ensuring sustainable development of future masters' scientific and tutorial culture.

The module "Organization and Operation" consists of several components: procedural, organizational and methodological. Procedural component reflects the process of development of a future master's scientific and tutorial culture. Organizational component determines pedagogic conditions that provide a "comfortable" environment for efficient development process of the scientific and tutorial culture (fig. 3).

Methodological component is determined by forms, methods and means for development of masters' scientific and tutorial culture. The choice of forms aimed at realization of the proposed model's aim is determined by a gradual involvement of master students in the development process

Fig. 3. Model of development of master students' scientific and tutorial culture



of the scientific and tutorial culture. It should be noted that it is valuable to introduce participative teaching and learning methods to master students' training [6]. The means are seen as material and ideal objects that can be used to ensure the introduction of the characteristics fostered to the system of engineering master students' personal characteristics. At this, it is rational to distinguish general didactic, technological and regulatory, and methodological means.

In order to evaluate the level of concordance between the expected and the achieved outcomes, as well as to receive feedback, the model includes a module "Integration and Evaluation". This module includes not only the criteria for development of scientific and tutorial culture of engineering master students, but also the levels necessary for correlating master students' outcomes in the process of their goal achievement.

Finally, it should be noted that the issue of developing master students' professional and project-oriented culture, as well as their scientific and tutorial culture is highly topical and is determined by the fact that master degree is the final stage of the full cycle of higher education that is aimed at training scientific and pedagogic elite of the society, rather than preparing a mass of specialists. Master degree envisages a deeper understanding of theory in the chosen field of study and a more thorough to train for scientific and tutorial activities in that field. One of the key aims of master programmes is training responsible, initiative and proactive agents of communication, cooperation and co-creation, with a high level of professional culture development. Therefore, in the context of the modern realm, the system of engineering master students' training should be reconsidered and the emphasis should be put on the development of the professional and project-oriented, as well as the scientific and tutorial cultures.

ENGINEERING EDUCATION AND TRAINING: CHALLENGES AND EXPERIENCE

ENGINEERING EDUCATION 21'2017

REFERENCES

1. Kaplina S.E. Professionalnaya kultura kak tsennostnaya osnova formirovaniya professionalno-mobilnoi lichnosti ingenera (Professional Culture as a Value Foundation of Engineer's Professional Mobility Formation) // Vestnik BGU. – 2015. – No. 1. – pp. 59–65.
2. Lipskaya L.A. Sovremennyi chelovek i mir obrazovaniya: predstavleniya i sotsiokulturnaya realnost (Modern Human and World of Education: Understanding and Sociocultural Reality) / L.A. Lipskaya, V.I. Lipskii // Socium i Vlast. – 2015. – No. 2. – pp. 122–126.
3. Malygina O.A. Etapy formirovaniya orientirovochnoi osnovy professionalnoi mobilnosti bakalavrov i magistrov v tekhnicheskom universitete (The Stages of the Development of Orientation Basis of Professional Mobility of Undergraduate and Graduate Students of Technical HEIs) // Izvestia: Herzen University Journal of Humanities & Science. – 2011. – No. 142. – pp. 111–118.
4. Novikova T.D. Proektnye tekhnologii na urokakh i vnutriurochnoi deyatelnosti (Project Technologies within Classes and Extracurricular Activities) // Narodnoe obrazovanie. – 2000. – No 7. – pp. 151–157.
5. Plotnikova O.A. Modelirovanie i algoritm formirovaniya professionalnoi kultury budushego bakalavra po napravleniyu "Reklama I svyazi s obshestvennostyu" (Design and Algorithm of the Formation of Future Bachelor's Professional Culture of "Advertisement and PR" Major) / Plotnikova O.A., Semenova L.M. – St. Louis, USA : Sci. & Innovation-Center, 2013. – 172 c.
6. Podpovetnaya Yu.V. Metody razvitiya nauchno-metodicheskoi kultury prepodavatelya vysshei shkoly (Methods of Development Scientifically-Methodical Cultures of the Teacher of the Higher School) [Electronic resource] // Modern research on social problems. – 2011. – Iss. 8, No 4 – p. 51 [21 p.]. – URL: http://cyberleninka.ru/article/n/metody-razvitiya-nauchno-metodicheskoy-kultury-prepodavatelya-vysshey-shkoly, free. – Tit. from the screen (usage date: 22.11.2016).
7. Fedotova A.D. Kontekstno-modulnyi podkhod kak osnova proektirovaniya osnovnykh obrazovatelnykh programme podgotovki magistrov [Context-Modular Approach as a Base of Designing of the Main Professional Educational Programmes for Masters' Training in Humanitarian Sphere] // Uchenye zapiski ZabGU. Seriya: Professionalnoe obrazovanie, teoriya i metodika obucheniya (Scolarly Notes: Theory and Methods of Professional Education). – 2014. – No. 6. – pp. 76–81.
8. Filimonyuk L.A. Formirovanie proektnoi kultury pedagoga v processe professionalnoi podgotovki: dissertatsiya doktora pedagogicheskikh nauk (Pedagog's Project Culture Formation within the Process of Professional Training: dissertation of doctor of padagogical science) / Filimonyuk L.A. – Stavropol, 2008. – 425 p.
9. Churakova M.V. Razvitie nauchno-metodicheskoi kompetentsii prepodavatelya uchregdeniya srednego professionalnogo obrazovaniya: dissertatsiya kandidata pedagogicheskikh nauk (Development of Scientific and Methodological Competence of a Vocational Education Teacher : dissertation of candidate of padagogical science) / Churakova M.V. – Chelyabinsk, 2010. – 190 p.

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Development of Integrated Management System in the Engineering School

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The article relates to integration of quality management systems of the university and the testing laboratory which is a part of the university according to the accreditation requirements to laboratories within the framework of the national accreditation system. It studies alternatives, areas, and degrees of the integration, and suggests a standard approach to IMS (Integrated Management System) based on ISO 9001 and ISO/IEC 17025 to eliminate possible risks in accreditation and allows achieving goals of the integrated management systems.

Key words: integrated management system, university, testing laboratory, accreditation, integration area.

Development of integrated management system (IMS) at universities has been actively discussed for the recent 5-7 years. A number of Russian universities – from technical to pedagogical ones – have already introduced and certified the IMSs based on diverse universal standards, such as ISO 9001, ISO 14001, OHSAS 18001, which is analogue of SA 8000, more rarely ISO/IEC 27000, applied to information security management systems. More and more universities have certificates for several management systems. Such trend proves the growing interest of universities in increasing efficiency of their work.

The reasons that induce Russian universities to implement IMS are different: some are aimed at enhancing the image of a university in the eyes of regulatory authorities and employers; others hope to be more compatible in grants and programmes, which makes an important part of university's image. There are other reasons that are not so clearly defined, for example: to implement the ways to solve problems of social responsibility and business ethics in academic community by introducing declarative provisions of ISO 26000 and its analogues.

The validation of new approaches in the framework of university IMS is delivered in research publications [1–3]. However, the analysis of the publications relating to the university IMS shows that the reasons for a university to choose ISO 14001, for example, to be implemented are not well grounded. Doing research work, universities do not produce emissions that would have negative impact on the environment. Thus, a university will not be able to identify the environmental aspects of its activity and to assess their importance in terms of legislation requirements, stakeholders, and risks (frequency, scale, severity of consequences, costs, control lost etc.). While determining these aspects a university should be governed by reasonable practicality, that is to limit itself to the aspects that can be justifiably controlled (first of all in terms of their relevant environmental impact). The university should not start implementing the requirements of the environment management system without assessing their relevance.

The integrated management system results from synergetic interaction of systems targeted at different spheres and applied to any organizations (universal standards of management system) and to organizations of particular industry (industrial standards of management system). The latter ones include the standards developed on the basis of ISO 9001 to be applied in particular industries, automobile – ISO/TS 16949, food – ISO 22000, petroleum industry – ISO/TS 29001, etc. The infrastructure of the international standards, used while developing IMS, can be developed by means of international standards for computerized scheduling systems, production and process modeling management (MRP, MRP II, ERP, CSRP, CALS, ARIS, IDEF, etc.), as well as standards for risk management, knowledge and assets management. However, though being aimed at increasing management efficiency, these standards are the tools to solve only technical tasks; thus, they can be regarded only as supporting tools for an organization to develop a system of continuous activity enhancement [4].

It is obvious that IMS should not be identified with the system of general management that unites all the activity aspects of the organization. In this regard, the notion "integrated management system" is of limited character, though being more complex than the notion about each separate management system united in IMS. Even with implementing all universal and industrial standards, IMS cannot substitute the system of general management, since it does not still include financial management, personnel management, innovative management, securities management, etc. The notions "integrated management system" and "system of general management" can be identical only after the standards for all spheres related to the general management are developed. Thus, it is reasonable to assume that IMS development will not be completed unless all the aspects of the general management are standardized, which is a dim and long process.

However, the relevance of developing highly integrated management system is doubtless. There are a number of obvious reasons [5]:

- IMS ensures more coordination inside the organization, thus adding to a synergetic effect, which means that coordinated actions lead to better result than the sum of separate results (according to Aristotle's paradox "one plus one is more than two");
- IMS minimizes functional lack of cooperation that results from development of separate management systems in the organization;
- IMS development is less labour consuming than development of several parallel systems;
- The number of internal and external connections in IMS is less than the total number of the connections in several systems; the amount of documents in the integrated system is much less than the total amount of documents in several parallel systems;
- IMS ensures high involvement of the staff in the activity enhancement;
- IMS can take into account the balance of external stakeholders' interests more effectively than the parallel systems can do;
- Costs for development, functioning and certificate of IMS are lower than the total costs for several management systems.

As practice shows, there are a number of ways to develop and implement IMS [6]:

- To develop additive IMS models; the system of environmental management (SEM), OHSAS, etc, are successively added to the quality management system (QMS). When using this way the gap between the introductions of the systems can vary from 6 months to several years;
- To develop fully integrated system; all management systems are united in one unit simultaneously. Though having obvious organizational and economical benefits, this way is still rarely used since it is difficult to be implemented.

The unified international standard for IMS implementation has not been developed yet. However, there are two documents that can serve as a base for such standard. It is a guide for ISO 72:2001 «Guidelines for the justification and development of management system standards», and PAS 99:2006 «Specification of common management system requirements as a framework for integration».

ISO 72:2001 has terminology, structure,

common elements of standards for management systems that can be developed by specialists of ISO departments and agencies. The guideline recommends using a widely known PDCA cycle and keeping to the process approach that is a base for ISO 9001.

PAS 99:2006 was developed with regards to ISO 72:2001 used for any new management system. PAS 99:2006 describes the system that would take into account common and specific requirements for management system standards.

Russian requirements to IMS are determined in national standard GOST P P 53893-2010 «Guidelines and requirements for integrated management systems». Certification association "Russian register" developed the rules to integrate management systems, based on the experience in certification activity.

Inefficient implementation of separate management systems (quality-, environmental management etc.,) and their integration lead to significant expenses and loss of stakeholders' confidence. IMS can effectively be implemented only on a new scientifically-grounded base, since this task is complicated and risky. Taking into account the culture level, it is reasonable to apply the additive IMS model described above.

While implementing INS in universities, there arise a number of problems to be solved:

- How can universities use the experience of other industry sectors in IMS development?
- How can the balance of all stakeholders' interests be kept while introducing IMS?
- How can IMS be developed to ensure efficient university activity and meet interests of all stakeholders?

It is of special interest for Kuban State Technological University to develop the additive IMS that takes into account specific work of testing laboratories that are part of the university. The activity of the laboratories is regulated by ISO/IEC 17025 and undergoes accreditation procedure by Rosaccreditatia according to the criteria established by the order of the Ministry of economic development of Russia no. 326, dated 30.05.2014.

Studying the market for food safety testing services, we observe the increase in the number of universities that provide the services of testing centers, which can be explained by a number of reasons:

- increase in the amount of domestic production and imported goods of the Custom Union countries;
- active work of EAEC structures to develop and introduce the Custom Union regulations for food industry, in particular, including nutrient additives, dietary products, packages, and labels;
- scientific aspect is taking more and more leading position in providing Master degree and post graduate degree programmes. Their quality is assessed in terms of efficiency of scientific innovative activity. Performance criteria for scientific innovative activity of universities are monitored by the Ministry of Education and Science on an annual basis.

QMS of a testing center ensures its efficient work. Efficiency is an essential prerequisite for survival in severe competition on the service market. Efficient QMS of the testing center should be an obvious benefit not only in the Russian but also the EAEC markets.

One of the six university testing centers that provide conformity assessment is Testing Center "Food Safety", Kuban State Technological University. It is certified by Rosaccreditatia. The Testing center provides the following services within the framework of its accreditation:

- to control quality and safety criteria for food, food commodities and feed;
- to control quality and safety criteria for foodservice industry;
- to control quality and safety criteria for perfumes and cosmetics;
- to conduct microbiological tests, including those for sanitary-indicative microorganisms.

The Testing Center (TC) is regularly accredited according to the Rosaccreditatia requirements. The QMS of TC is independent (quality policy, system-wide procedure, "dependent" internal audit, etc.) and developed to meet ISO/IEC 17025 requirements. At the same time, TC is a structural division of Kuban State Technological University (KubSTU) and can use system-wide procedures of KubSTU QMS that comply with ISO 9001 and are required by ISO/IEC 17025. It makes it necessary to integrate two systems in one to ensure both ISO 9001 and ISO/IEC 17025 compliance.

Nowadays, there is no unified conceptual approach to the additive IMSs. The guidance to IMS implementation in universities has not been developed yet. To facilitate the integration of TC QMSs in KubSTU QMS, a standardized approach to the additive model of university IMS based on integration of ISO 9001 and ISO/IEC 17025 has been developed.

To achieve the integration goals, the following tasks were performed:

- to study the regulatory documents of Rosaccreditatia relating to testing centers (laboratories) accreditation and international standards with respect to conformity assessment;
- to study the experience of TCs accreditation in the CIS;
- to compare QMS procedures and documents of KubSTU and TC;
- to choose areas and degree of IMS integration, to develop KubSTU IMS structure that includes interaction of processes, integrated activities and documents;
- to describe the TC process "Assessment of compliance";
- to develop the procedures of the integrated audits that would meet the integrated requirements of the Ministry of Education and Science, Rosaccreditatia, and IMS annual report.

According to the Federal Act "On accreditation" No. 412-FZ of 28 December 2013, certification bodies and testing laboratories should be technically competent. The order of the Ministry of Economic Development of Russia No. 326 of 30 May 2014 "On Approval of the accreditation criteria and the list of documents to confirm the applicant's compliance with the accreditation criteria" contains the requirements to the technical competence and quality management system of a testing laboratory. These requirements are necessary to ensure technically grounded data and test results. The order contains reference data on the standards for compliance assessment, ISO/IEC 17025 in particular, the provisions being included in the criteria in interpreted form. Additional requirements of the national accreditation system are to confirm legal ownership of premises, testing equipment and other facilities (par. 21), and ensure measures to prevent interest conflict (par. 23.4). The QMS documents of a testing laboratory, apart from the required according to ISO/IEC 17025, are to include employers' viewing the documents, administration of database for all external regulatory documents (par. 23.7), the rules to describe corrective measures (par. 23.17), and use of the national accreditation system label (par. 23.22).

To develop additive model of university IMS, integration areas were determined, that is a combination of integrated standards with the most similar features. These elements are summarized in table 1.

The comparative analysis shows that GOST ISO/IEC 17025 and Accreditation criteria do not implement a process approach, and the latter do not have the requirements for customs' satisfaction assessment. While the elements being integrated, the university's limits in IMS implementation were taken into account. They are related to the availability of resources to implement the integration and the willingness of the TC to change: how deeply the TC personnel understand the integrated approach and customs' survey.

The TC does not determine processes in the QMS. However, the test results provided to a customer are the results of its activity that has all characteristics of a process – repeated interacted and interconnected activities that transform input into output, and other characteristics of a process [7]. The sample testing for compliance assessment includes the following stages:

- to make contract for testing;
- to choose methods of testing;
- to prepare for tests;
- to perform tests;
- to make a protocol of tests.

Table 1. Requirements to the key elements of IMS in ISO 9001 and ISO/IEC 17025 and accreditation criteria

QMS element	ISO 9001	ISO/IEC 17025	Accreditation criteria
Quality policy	+	+	+
Quality goals	+	+	+
Process management	+	–	–
Document management	+	+	+
Quality manager	+	+	+
Management of monitoring and measuring equipment	+	+	+
Management analysis	+	+	+
Consumer satisfaction	+	+	–
Internal audit	+	+	+
Continuous improvement	+	–	–

Fig. 1. "Compliance assessment" process layout

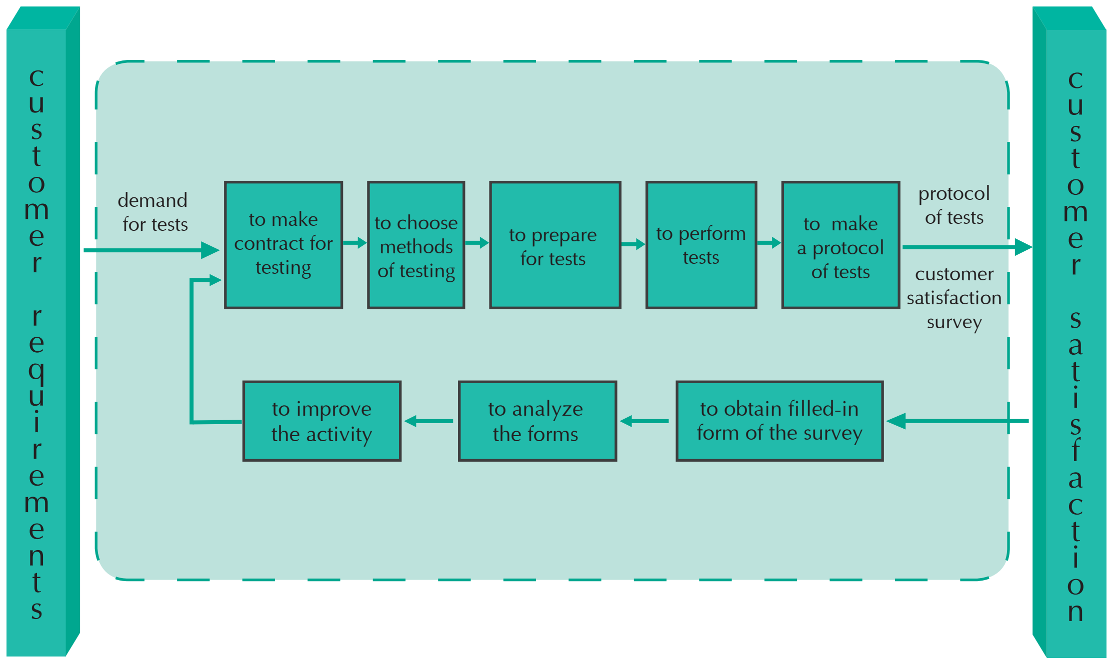

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Table 2. Monitoring and measuring criteria for "Compliance assessment" process

Process stage	Indices of the process and its target value
to make contract for testing	The contract is made (yes/no) Agreement deadline (no more than 2 days)
to choose methods of testing	The possibility to perform tests with the equipment available at TC and approved for use by the guidance (yes/no)
	Compliance with the accuracy characteristics of the testing procedure required for the tested sample (yes/no)
to prepare for tests	Compliance with the required environmental conditions (yes/no)
	Availability of all the necessary certified standard samples, reagents and materials (yes/no)
	Calibrated measuring facilities and certified equipment (yes/no)
to perform tests	The accuracy of parallel test results complies with the required value (not less than 2)
	Assessment of test result adequacy (yes/no)
	The final test result is compared with the standard sample values (yes/no)
	The requirements for terms of service provision are met (yes/no)
to make a protocol of tests	The number of mistakes in the test report (no more than 1 mistake that does not interfere with the test results)
	The test report is delivered to the customer within the period established by the contract (yes/no)
	The customer is satisfied with the service quality (satisfaction rate is not less than 70% according to the survey)

"Compliance assessment" IMS process and the criteria are shown in fig. 1 and in table 2.

The suggested approach to IMS allows reaching the following degree of integration:

- a unified system coordinator who uses unified approaches to the whole management system;
- a common harmonized quality Policy added with responsibilities of TC relating to compliance assessment services;
- a unified and well-balanced planning framework, goal setting and reporting processes;
- unified system-wide QMS procedures required by the integrated standards;
- a unified database that includes a QMS register and documents available for all users;
- a complex system that ensures optimal provision of all resources and facilities;
- a unified system for staff training and development;

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- a unified programme of internal audits and social surveys;
- an annual QMS analysis is carried out with regard to TC activity assessment according to the process "Compliance assessment".

IMS implementation optimizes functions and flow of documents, thus breaking down the barriers and saving IMS costs. We keep to the following principles: not to destroy the existing QMS of TC, to minimize all possible accreditation risks, and to ensure the possibility of increasing the volume and quality of the services provided as well as its work efficiency. Positive results from IMS implementation can only be obtained on condition that the TC management team and all the staff are involved in the process.

REFERENCES

1. Simonova A.A. Integrirovannaya sistema menedzhmenta pedagogicheskogo universiteta [Integrated management system of pedagogical university]. Akkreditaciya v obrazovanii [Accreditation in education], 2014, no.3, pp. 26–28. (In Russ., abstr. in Engl.).
2. Pisarenko K.E. Kvitko V.J. Ekologicheskii menedzhment v obrazovatelnom uchrezhdenii [Ecological management in educational institution]. Nauchnyi zhurnal NIU ITMO Ser Ekonomika i ekologicheskii menedzhment [Scientific journal NRU ITMO Series "Economics and Environmental management], 2014, no. 2, pp. 10–23. (In Russ., abstr. In Engl.).
3. Chuchalin A.I. Zamyatin A.V. Upravlenie obrazovatelnoi deyatelnostyu v integrirovannoi sisteme menedzhmenta kachestva vuza [Education management in integrated management system]. Voprosy obrazovaniya [Educational studies], 2010, no. 1, pp. 116–133. (In Russ., abstr. in Engl.).
4. Zaika I.T Smolentsev V.M. Fedulov YU.P. Sistemnoe upravlenie kachestvom i ekologicheskimi aspektami [Systematic quality and environmental management]. Moscow: Publ. INFRA-M. 2014. – 384 p.
5. Svitkin M.Z. Integrirovannye sistemy menedzhmenta [Integrated management system]. Standarty i kachestvo [Standards and quality], 2004, no.2, pp. 32–34. (In Russ., abstr. in Engl.)
6. Katanaeva M.A. Additivnaya integrirovannaya sistema menedzhmenta predpriyatiya [Additive integrated management system of an enterprise]. Rossiiskoe predprinimatel'stvo [Russian journal of entrepreneurship], 2009, no. 7, pp. 36–40. (In Russ., abstr. In Engl.).
7. Al'-Busaidi S.S.S., Sosedov G.A. Ponomarev S.V. Formirovanie, vnedrenie i prakticheskoe primenenie protsessov sistemy menedzhmenta v ispytatel'noi laboratorii, orientirovannoi na proizvodstvennuyu, kommercheskuyu i obrazovatel'nuyu sfery deyatel'nosti [Development, implementation and application of management system in a testing laboratory focused on industrial, commercial and educational; activities]. Monograph. Tambov: Publ. TSTU. 2012. – 120 p.

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Socially Oriented Approach: Professional and Personal Competencies of Engineering Graduates

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The paper addresses development of engineering graduates' competencies in terms of social position rather than economic, traditional, viewpoint. It emphasizes the importance to develop internal University culture that brings up engineers' responsible attitude to their professional activity. The authors provide some survey data related to TPU students' internal culture research.

Key words: university graduate's competencies, responsibility, university internal culture, engineering education, engineer.

"The first duty of the university is to teach wisdom, not a trade; character, not technicalities".
W. Churchill

Today, the concept "engineer" implies three categories of people [1].

The first category embraces people who occupy engineering positions. They should meet the requirements set both by the government regulations and industry-specific regulatory documents.

For example:

- Third grade engineer: higher professional (technical) education, work experience is not required; or vocational (technical) education, not less than three-year work experience in a position of the first grade technician or other positions (not less than five-year work experience for vocational degree holders).
- Second grade engineer: higher professional (technical) education, three-year work experience in a position of an engineer or other engineering positions.
- First grade engineer: higher professional (technical) education, not less than three-year work experience in a position of a second grade engineer.

The position of an engineer is gradually vanishing in Russia. It is replaced by such posts as "specialists", "expert", etc.

The second category involves people who graduated from the university with a degree in engineering or were accredited by a professional-public accreditation agency after submission of all required documents or passing corresponding exams.

The first group of people within this category embraces those who had graduated from university before Russia adopted a two-tier (Bachelor, Master) degree system. In reality, the two-tier degree structure of education system was adopted by some Russian universities in 1993, though Russia signed the Bologna Declaration in 2003. In 2011, Russian universities eventually moved to the two-tier bologna system of education. This group comprises the working age population.

The second group is a relatively new phenomenon. In Russia, it appeared approximately in 2011. It is worth noting that the degree of engineer has been awarded in the western countries (with exception of Germany) by definite professional-public accreditation agencies for a long period of time. Western universities have never awarded their students such a degree. In

Russia, the lack of the engineering legislation impedes the sharp increase in the number of people awarded the degree of engineer by the professional-public accreditation agencies.

Finally, the third category is comprised of people who are directly involved in engineering activity. They may hold corresponding degrees and occupy engineering positions. However, it is not obligatory for this category.

Engineering is termed as an activity aimed at practical application of scientific, economic, and social knowledge in order to secure efficient use of natural resources with benefits for people [2]. The main objectives of engineering are to invent, innovate, design, build, maintain or improve structures, machines, materials, and processes. Engineering is closely interwoven with science. It rests on the postulates of the fundamental science and findings of practice-oriented research.

A vision for the engineer of the future is being intensively discussed [3-6]. Without going into detail of various engineering degree training, it is possible to outline a number of general considerations.

Speculating on the vision for the engineer of the future, first of all, one should bear in mind a wide range of engineering tasks an engineer should be able to tackle even within the scope of one engineering discipline. From the above-mentioned objectives of the engineering activity, it is obvious that an engineer may either be involved in absolutely creative work (invention, design, implementation) or perform routine engineering tasks (maintenance, repair, improvement). To effectively manage all these activities, an engineer should acquire a set of professional and personal competencies. In addition, unequal distribution of creative and routine work, also within the process of technological innovation, should be considered. Thus, a designer may need dozens, perhaps thousands (depending on the complexity of the designed products) of detail draftsmen whose work requires less or even no creativity.

Relating to the professional competencies, an engineer involved in creative work must demonstrate a deep insight into various branches of both fundamental and applied science (for aircraft designers it is essential to know how birds really fly), while an implementation engineer or machine engineer who is in charge of maintenance, repair, and improvement of machine, processes, and materials should have knowledge of the regulatory documents, standards, definite properties and specifications of the machines and equipment he/she works with.

The personal competencies can vary. An engineer-designer who, indeed, creates the future is a leader both at rational and intuitive levels (suffice it recall the story about S.P. Korolev, a designer of space aircrafts, who wrote the following in response to the demand to prove that the lunar surface vehicle would not drown in lunar dust "The moon is hard!" and signed the document). Such talented people are not often open to communication, do not wish to subject, like to take risks, etc. and, as a rule, it is useless to reeducate them.

An implementation engineer or machine engineer, vise verse, should be sociable, ready to subject and avoid risky actions.

Hence, the wrong conclusion can be made that universities should take into account the difference in characteristics of various types of engineers and correspondingly correct the number of graduates trained within this or that engineering specialization. It is this conclusion that forces Russian universities to increase the number of various engineering degree programmes, introduce new disciplines into the curricula and carry out a great number of tests to divide students into the groups according to their abilities.

Also, when developing the requirements to the engineer of the future, the opinion of an employer should be treated with caution.

The timeframe that the modern business plan covers seldom exceeds a year, especially in the context of crisis. The business owners are not capable of defining what type of machinery and equipment they will use in 3-5, all the more 10 years. At the same time, the timeframe of university plans varies from 4 to 6 years (curriculum is usually developed for the entire study period). In addition, university is a cradle for science, it means that new machinery and technologies are conceived at universities on the basis of up-to-date scientific achievements. This fact is seldom considered by employers when formulating the requirements to engineering graduates. Evidence of this phenomenon can be found in the results of the practical course carried out several years ago at National Research Tomsk Polytechnic University (TPU) [7]. The training course was designed for TPU faculty, business owners and specialists of a number of Tomsk enterprises. They were asked to formulate the requirements to TPU graduates. It was revealed the university faculty made up a list of certain requirements, while potential employers restricted themselves to general phrases and memories of the "kind" past.

Another important factor to be considered in formulating requirements to the engineer of the future is elimination of the imbalance between professional and personal competencies.

More attention is now paid to the development of professional competencies. It is enough to look through the list of competencies for a graduate to achieve upon any programme completion in order to notice this imbalance.

As a rule, the list of competencies always contains such a competency as "responsibility", however, it is usually understood as responsibility for the entrusted work that should be done at any cost, rather than responsibility for what you do. From this perspective, a chemical engineer who invented new poisonous gas upon instructions from the authorities is a rather competent engineer.

Besides, the present education degree programmes do not clarify when and how such a competency as "responsibility" is developed.

Nowadays, as machinery and technologies intensively develop, responsibility of engineers becomes more important. The lack of responsibility could result in severe technogenic disasters. It is enough to recall the 1986 disaster at the Chernobyl Nuclear Power Plant, failure at Sayano-Shushenskaya hydroelectric dam, accident at the Fukushima Daiichi nuclear power plant… The responsibility of an engineer will become more and more important. Hence, this competency should be particularly emphasized within the scheduled engineering curricula.

The issue of training engineers of the future is closely interwoven with the changes in social structure and organization of the society.

The modern Government and, to some extent, the society itself are trying to impose constraints on the universities so that they "produce screws" for the economic machine. In order to guarantee that this "screw" fits for its purpose (make profit), it should be properly designed (initial parameters should be correctly set), properly produced (abundant characteristics and possibilities should be eliminated), properly used (place it where it is designed to work). Hence, a lot of attempts are made to identify students' unique strengths at the stage of entrance exams in order to build appropriate study paths that would ensure so-called "screw production". Fortunately, all these attempts regularly fail, however, persistence in this issue gives reasons for concern.

The question is how to evaluate the scope of engineering activity in engineering training?

Today, this scope is defined by the life itself. A graduate found him/herself at a real workplace can try any activities within his/her position or occupation and, as a result, choose those which suit him/her better. Despite some obvious efforts, this way is proved to be the best one.

Due to the above-mentioned inertia, higher education would never meet up-to-the-minute requirements of the economy. Therefore, universities should equip their graduates with some crucial fundamental and practical competencies, personal attributes, willingness and capability of pursuing further education within the chosen domain. A graduate should not only display a deep knowledge of his/her profession (it would never be possible to know everything), but, first of all, demonstrate ability to think. This is, actually, in consistent with the employers' requirements. The workplace needs analysis has revealed that emphasizing the need for highly-qualified workers, employers usually expect their workers to demonstrate not specific knowledge and competencies, but definite level of thinking, experience, and responsibility.

It is reasonable to introduce such an education system so that each person would have a possibility to attain required knowledge and skills precisely at the moment he/she needs them (lifelong learning), but not in advance. Therefore, the emphasis should be made on the retraining courses which are currently regarded as a non-core activity that brings profit both to university and faculty members. However, it should become the basic activity of the universities along with teaching within the core degree programmes. This approach will be in consistent with the above-mentioned education system when the degree "engineer" is awarded by professional-public accreditation agencies.

It is required to clarify terminology in the system of retraining education, which would eliminate the existing confusion. For example, it is absolutely unclear what level of knowledge the Diploma of Professional Retraining and Advanced Training Certificate imply. What is more important is that how these levels of knowledge relate to that gained upon completion of bachelor's and master's degree programmes.

Such approach to basic and additional education stipulates the changes in planning, organization, and implementation of the training process itself, as well as fosters the understanding that faculty members involved in basic and retraining programmes should meet different requirements.

Hence, the employers should be engaged in formulating the requirements to the competencies of retraining programme graduates, but not to the graduates of the core degree programmes. Within the retraining education, the opinion of employers is of particular importance.

However, first of all, it is required to initiate three key changes in the society, which would contribute to training the engineer of the future:

1. To develop and approve the Doctrine of Engineering Education in the Russian Federation (RF), or, perhaps, the Doctrine of Education of the RF.

2. To develop and approve the Law of the RF "On Engineering Activity".

3. To develop and implement a set of actions aimed at enhancing the image of an engineer.

When it comes to personal competencies (the term itself is rather improper), i.e., first of all, responsibility, it is worth noting that it is quite a complicated task to develop it. To resolve the task, it is important to create a certain environment at the university – organizational culture – which would both directly and indirectly influence personality of a graduate.

The university community is comprised of two groups of people: constant group – faculty members, and inconstant group – students. Based on this statement, it is possible to assume that the organizational culture of university involves two subcultures.

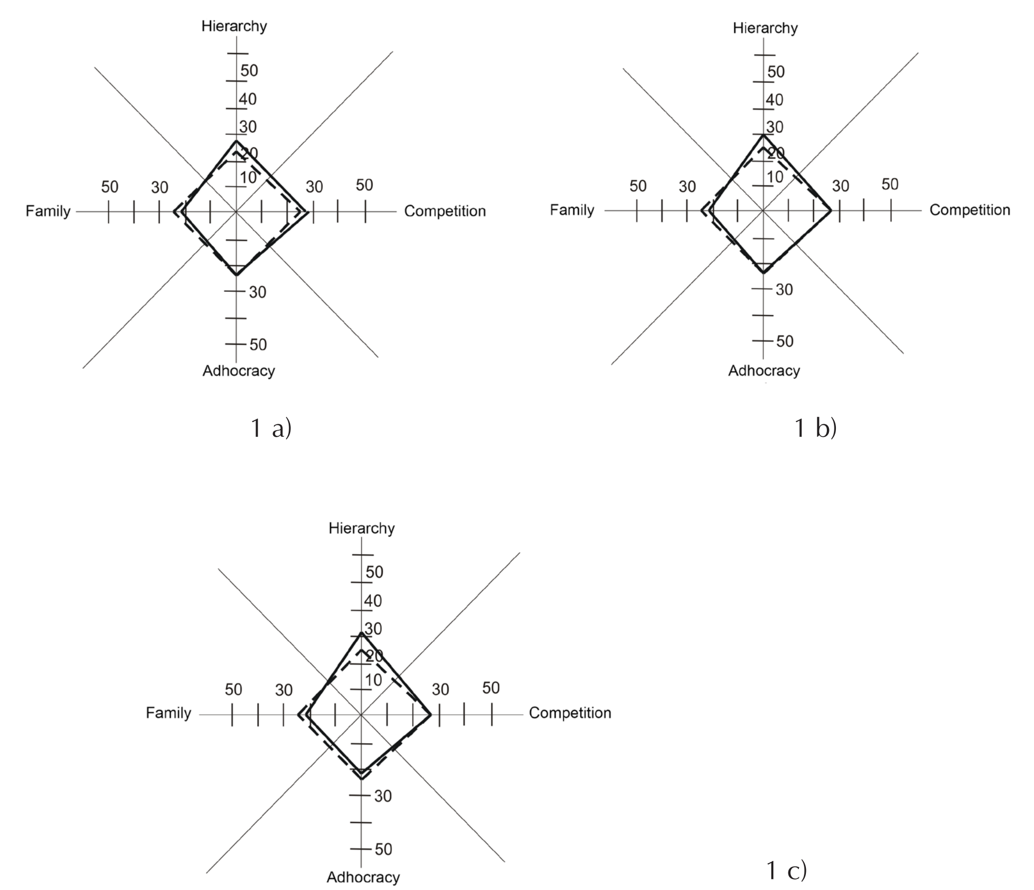
The organizational culture of the faculty members is currently being intensively discussed. The quite interesting findings are presented in [17-22].

The student organizational culture usually implies sport, amateur performances, volunteer work and other similar student activities [8-16]. However, despite the obvious importance of the above-mentioned activities, it is essential to remember that personal competencies are basically shaped in the process of training and research. It is this close interaction with a supervisor, a teacher that shapes the world view and values of a future graduate during training and research process. Scientific schools which are comprised of professors and students who share the same views, ethics, and values are the best examples. Therefore, of particular interest is to analyze the student organizational culture by means of the methods and perspectives applied in the analysis of the faculty organizational culture. In addition, the two cultures can be compared.

To address this task, the organizational culture of TPU students was analyzed via the Organizational Culture Assessment Instrument (OCAI) [20]. The typical questionnaire of this instrument was adapted to the level of students' reception of the organizational culture. This modification of the instrument was agreed with the developers of OCAI. In addition, in order to be sure that students understand the questions correctly, a number of seminars were conducted involving various year students. These seminars enabled students to discuss the organizational culture both in a free format and via the questionnaire. It helped students adequately understand the principles of the questionnaire. 2000 questionnaires were distributed among the bachelor's students of the 1st and 4th year of education and master's students of TPU (the total number of full-time students at TPU was 9944 in 2016). Once students completed the questionnaires and the spoilt questionnaires were separated, 1762 questionnaires were accepted for further analysis.

Fig. 1 a) and 1 b) show the organizational profiles of bachelor's students of the 1st and 4th year of education, while fig. 1 c) shows the organizational profile of master's students (full lines – "now" culture,

Fig. 1. Organizational profiles of TPU students



dashed lines – "preferred" culture).

As shown in fig. 1, the current organizational profile is approximately uniform for all students of TPU (the 1st, 4th year students and master's students). It means that almost all subcultures are presented in all quadrants. There is slight emphasis on the hierarchy quadrant (about 30 points), which is considered normal for such a huge organization as TPU. The "Preferred" profile is absolutely uniform. The discrepancy between "Now" and "Preferred" organizational profiles is insignificant, which means that students do not wish to change anything at the university.

The organizational profiles of definite degree programmes and institutes show the similar trends, which proves the uniform character of TPU structure. It means that there are no specific subcultures in various institutes of TPU.

Fig. 2 shows the organizational profiles of TPU faculty members [19].

It is obvious that the organizational profiles presented in fig. 1 and 2 are almost the same. The close examinations of the organizational profiles of students and faculty members of certain TPU institutes has revealed that the faculty organizational profile deviates from the average value of TPU at the same way the student organizational profile does. It is shown in fig. 3 which presents the organizational profiles of faculty members and master's students of Institute of Humanities and Social Technologies, TPU.

The findings of the current research prove that the organizational culture of the university is powerful enough to swallow up new-comers who, as a result, have to accept this culture being unable to resist. The deviations from this culture are severely punished. As the main contributors to the organizational culture of the university are faculty members and authorities, they have a possibility to impose their vision of the organizational culture on students, which is actually obvious from the analyzed profiles.

Such situation requires from the university authorities and faculty members to pay serious attention to formulating their own organizational culture, as this culture is further transmitted through students into the society and state. Upon university completion, students display the values which they have taken over in the course of education. Since the organizational cultures of most Russian technical universities are similar [18], this type of culture could easily dominate in our society and state.

As it was mentioned above, responsibility for what one does is one of the most crucial personal competencies of an engineering graduate. Therefore, the organizational culture of the university should become the best example of such responsibility. The faculty members should illustrate what such responsibility means by all of their activities. In this regard, an educator who gives classes half-assedly (students are usually attuned to such cases) because he/she is currently preparing the article for submitting into the scientific journal with high impact-factor, completely destroys the image of a responsible person so that no conversations and seminars could compensate for it. Thus, the systems of faculty motivation should, at least, equally stimulate efficient scientific research and qualitative class delivery.

Fig. 2. Organizational profiles of TPU faculty members

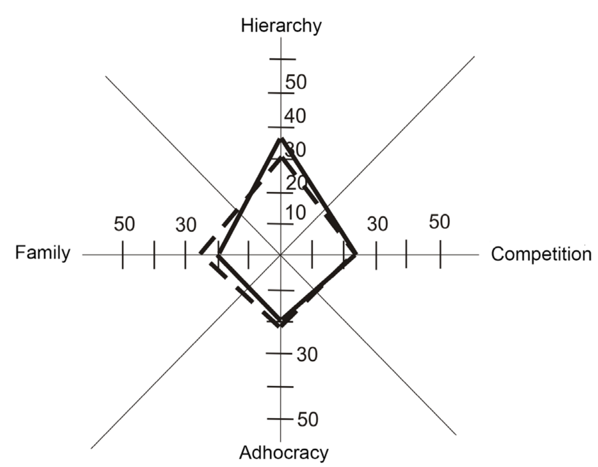
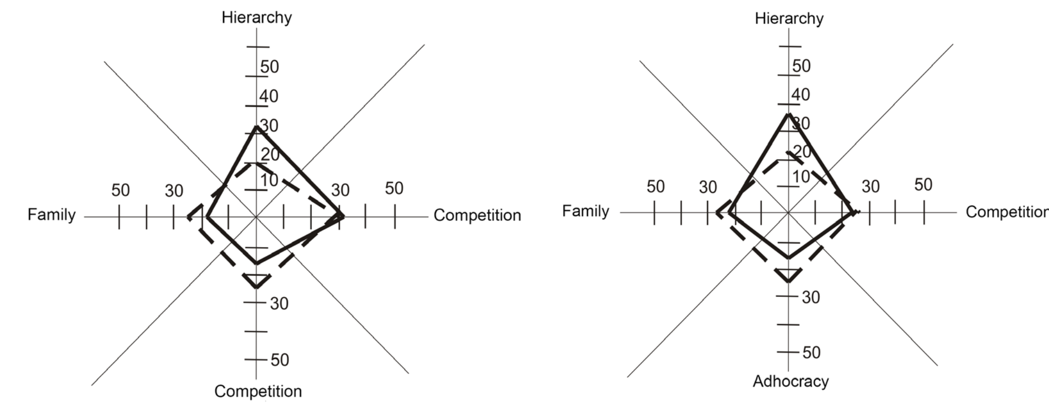


Fig. 3. Organizational profiles of faculty members and master's students of Institute of Humanities and Social Technologies, TPU.



faculty *master's students*

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ENGINEERING EDUCATION AND TRAINING: CHALLENGES AND EXPERIENCE
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REFERENCES

1. Inzhener [Engineer]. Wikipedia: free encyclopedia. [site]. URL: https://ru.wikipedia.org/wiki, free (accessed: 09.12.2016).
2. Inzhenernoe delo [Engineering activity]. Wikipedia: free encyclopedia. [site]. URL: https://ru.wikipedia.org/wiki, free. (accessed: 09.12.2016).
3. Novoselov V.V., Spasibov V.M. Inzhenernyj specnaz jekonomiki. Kakim dolzhen byt' specialist, vostrebovannyj segodnja i zavtra? [Elite Engineers for Economy. Who is the Highly Demanded Specialist of Today and Tomorrow?]. Inzhenernoe obrazovanie [Engineering Education]. 2015. № 18. – pp. 7–14.
4. Solov'ev V.P., Pereskokova T.A., Krupin Yu.A. Formirovanie kompetentnostej vypusknikov inzhenernyh programme [Development of engineering graduates' competences]. Inzhenernoe obrazovanie [Engineering Education]. 2015. № 18. – pp. 51–63.
5. Sigov A.S., Sidorin V.V. Trebovanija k inzheneram v uslovijah Novoj Industrializacii puti ih realizacii [Requirements applied to engineers in view of Modern Industrialization and the ways of their fulfillment]. Inzhenernoe obrazovanie [Engineering Education]. 2012. № 10. – pp. 80–91.
6. Chuchalin A.I., Boev O.V. Trebovanija k kompetencijam vypusknikov inzhenernyh programme [Requirements for engineering graduates' competencies]. Vysshee obrazovanie v Rossii [Higher education in Russia]. 2007. № 9. – pp. 25–29. (In Russ., abstr. in Engl.)
7. Pushnykh, V. A. Change of the university management system for enhancing the employability of graduates [Elektronnyi resurs]. Employability of graduates and higher education management systems (Final report of DEHEMS project): Proc. DEHEM Int. conf., Vienna, Austria, 22–23 Sept. 2011 / WU Vienna Univ. of Economics and Business. – Ljubljana: Univ. Ljubljana, Fac. Soc. Sci., 2012. pp. 216–225. URL: http://www.dehems-project.eu/static/uploaded/files/files/resoults/ZBORNIK_Part_I_-_Vienna_final.pdf#page=216, free. (accessed: 09.12.2016).
8. Shherbakova, M. V. Ovladenie korporativnoj kul'turoj v processe adaptacii pervokursnikov k obucheniju v VUZe [Understanding of the corporate culture in the process of first-year students adaptation to university]. The Bulletin of Voronezh State University. 2012. № 1. – pp. 164–168. (In Russ., abstr. in Engl.)
9. Chizhikova, E.S. Formirovanie korporativnoj kul'tury studencheskogo soobshhestva VUZa: avtoref. dis. kand. ped. nauk [Formulation of student corporate culture at the university: Ph. D. (Pedagogy) Thesis]. Moscow. 2010. – 23 p.
10. Onishhenko, O.V. Fenomen korporativnoj kul'tury VUZa v sisteme razvitija poznavatel'noj aktivnosti studentov [The phenomenon of the corporate culture of the university system in the development of the cognitive activity of students]. Vestnik Vjatskogo gosudarstvennogo universiteta [The Bulletin of Vyatsky State University]. 2011. № 3–1. – pp. 137. (In Russ., abstr. in Engl.)
11. Mal'ceva, G.I. Universitetskaja korporativnaja kul'tura [University corporate culture]. Universitetskoe upravlenie: praktika i analiz [University management: practice and analysis]. 2005. № 2. – pp. 95–103. (In Russ., abstr. in Engl.)
12. Dorokhina, R.V. Jeticheskie principy i cennostnye ustanovki studencheskih korporacij Evropy i Severnoj Ameriki [Ethic principles and values of student communities in Europe and North America]. Moscow: Publ.Prospect, 2015. – 128 p.
13. Andomin, O.V., Kosinova, S.N. Korporativnaja kul'tura studenchestva kak odin iz instrumentov processa vospitanija lichnosti [Corporate culture of students as a tool of a person's education process]. Vestnik Samarskogo gosudarstvennogo tehnicheskogo universiteta. Psihologo-pedagogicheskie nauki [the Bulletin of Samara State Technical Univeristy. Pshyco-pedagogical science]. 2011. № 2. – pp. 4–12. (In Russ., abstr. in Engl.)
14. Jablonskene, N.L. Korporativnaja kul'tura sovremennogo universiteta [Corporate culture of modern university]. Universitetskoe upravlenie: praktika i analiz [University management: practice and analysis]. 2006. № 2. – pp. 7–25. (In Russ., abstr. in Engl.)
15. Zaharova, L.N. Organizacionnaja kul'tura universiteta v kontekste problem diagnostiki i formirovanija gotovnosti studenta k rabote v uslovijah sovremennogo predprijatija [organizational culture of university in terms of the issues of diagnosing and forming readiness of a student to work under the conditions of a modern enterprise]. Universitetskoe upravlenie: praktika i analiz [University management: practice and analysis]. 2006. № 2. – pp.31–39. (In Russ., abstr. in Engl.)
16. Mal'ceva, G.I., Gorshkova O.V. Rol' korporativnoj kul'tury v formirovanii jeffektivnogo universiteta [Role of corporate culture in creating effective university]. Universitetskoe upravlenie: praktika i analiz [University management: practice and analysis]. 2006. № 2. – pp. 40–44. (In Russ., abstr. in Engl.)
17. Pushnykh, V.A. Genom universiteta [Genom of University]. Universitetskoe upravlenie: praktika i analiz [University management: practice and analysis]. 2016. № 103. – pp. 23–31. (In Russ., abstr. in Engl.)
18. Pushnyh, V.A., Pokholkov, Yu.P., Mitrofanova M.V. Korporativnaja kul'tura rossijskih tehnicheskih universitetov [Corporate culture of Russian technical universities]. Alma Mater (Vestnik vysshej shkoly) [Alma Mater (High Scholl Herald)]. 2011. № 7. – pp. 66–71. (In Russ., abstr. in Engl.)
19. Pushnyh, V.A. Sravnitel'nyj analiz organizacionnyh kul'tur rossijskogo i amerikanskogo universitetov [Comparative analysis of organizational culture of Russian and American universities]. Voprosy obrazovanija [Educational studies]. 2010. № 4. – pp. 291–306. (In Russ., abstr. in Engl.)
20. Cameron, K.S. Diagnosing and changing organizational culture: Based on the competitive values framework / K.S. Cameron, R.E. Quinn. San Francisco: Wiley Imprint, 2014. – 268 p.
21. Makarkin, N.P., Tomilin O.B., Britov A.B. Rol' organizacionnoj kul'tury v jeffektivnom menedzhmente vysshego uchebnogo zavedenija [Role of organizational culture in effective management of university]. Universitetskoe upravlenie: praktika i analiz [University management: practice and analysis]. 2004. № 5-6. – pp. 152–162. (In Russ., abstr. in Engl.)
22. Mkrtychjan, G.A., Petrova O.V. Problemy diagnostiki organizacionnoj kul'tury innovacionnogo universiteta [Some problems of diagnosing the organizational culture of an innovation university]. Vestnik NNGU im. N. I. Lobachevskogo: Innovacii v obrazovanii [Vestnik of Lobachevsky University of Nizhni Novgorod: innovations in education]. 2012. № 6. – pp. 22–27. (In Russ., abstr. in Engl.)


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UDC 374.3

Professional-Oriented Educational Environment for Supporting the Development of Children's Technical Creativity on the Basis of Network Integration of Infrastructure Resources of Educational Organizations

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The article presents the concept of network interaction of regional educational organizations within the framework of the programmes supporting children's technical creativity. The urgency of the development of mechanisms for network interaction is considered. An example of realization of network interaction within the framework of the project "Medical measuring systems and robotics" is given. The project is aimed at popularization among schoolchildren and young people of research activities in the field of electronic and technical devices.

Key words: technical creativity, additional education of schoolchildren, professionally oriented environment, basic technical educational platform.

Rationale

Today one of the most priority areas for the development of additional education for children and young people is the formation of conditions for updating and supporting educational programmes of research and applied orientation aimed at popularization of blue-collar jobs and engineering professions within the priority areas of science and technology development in the Russian Federation [1]. Improving the effectiveness of educational programmes in these areas is associated with the acute shortage experienced by the additional education organizations of a region, in modern equipment and logistics, educational and methodological developments and specific information resource support. Similar problems were outlined among the most acute issues in the Concept for the Development of Additional Education for Children, approved by the decree of the Government of the Russian Federation (04.09.2014, No. 1726-p). In addition to the v logistics problems the implementation of high-tech educational programmes faces lack of qualified personnel, who, in addition to modern pedagogical technologies, has a considerable amount of knowledge and skills in certain fields of science and technology development.

The process of learning, including the programmes of additional education, is inextricably connected with the process of learning environment development. The success of the educational process and the quality of training depend to a large extent on the degree of students' involvement in the learning environment, their individual perception or personal unacceptability of the norms and structure of the learning environment, and the ability of the learning environment to satisfy the information, legal and other needs of the learning process. In modern Russian pedagogy, the problem of creating a professionally oriented educational environment was considered in the works of B.N. Bogatyr, N.F. Maslova and V.V. Gusev, M.V. Clarin, V.A. Kozyrev, M.S. Chvanova, A.V. Khutorskoy and other scientists. For example, V.V. Gusev and N.F. Maslova within the framework of this approach consider the formation of an educational environment based on the integration of socially developing and professionally oriented pedagogical technologies that would ensure the realization of the students' cognitive activity in various types of educational activity.

Until recently in some regions of the Russian Federation, the solution of tasks related to the involvement of schoolchildren and young people in the process of additional education was associated, to a greater extent, with the activities of non-profit organizations. However, the implementation of such programmes, especially in the field of technical disciplines and research activities turns out an impossible task for non-profit organizations due to the above-mentioned problems, related to the limited personnel and financial support, as well as lack of appropriate infrastructure. For example, in Volgograd Region, based on the Decree of the Government of the Volgograd Region No. 649-p of December 29, 2012 "On the approval of the long-term regional targeted programme "Support to socially-oriented non-profit organizations of the Volgograd region" for 2013-2015 period, the following significant problems arise [2, 3]:

- unformed system and imperfection of the mechanisms of support for NGOs from the state;
- underdeveloped system of social order;
- lack of a system registering socially-oriented NGOs – recipients of support;
- insufficient public awareness on the activities of NGOs;
- low civil activity and legal literacy of the population of the Volgograd region;
- imperfect system of interaction of executive bodies of state authorities, local self-government bodies of municipal entities with public associations.

Nevertheless, the task of attracting schoolchildren and young people in the field of applied high-tech activities, as well as research work, is considered by the state as a priority task. Overcoming these issue will promote scientific, technical and, in particular, and military potential development.

Professionally oriented educational environment

The most effective way to solve the above stated problems could lay in a holistic approach aimed at integrating the resource capabilities of various educational sites offering additional education programmes. At the same time, it would help to develop a unified, integrated educational environment that could activate the mechanisms to support actualization, formation and sustainable development of research and applied activities of schoolchildren in the field of technical and natural sciences, accumulating the resources of educational institutions, training centers and technological platforms available in the regions.

Assuming the accumulation of knowledge by schoolchildren as the inertial process of developing professional and social competencies [4], it is important to consider the development of an educational environment as the design of a multilevel system providing consistent support and motivation for the development dynamics of schoolchildren in the field of research, technical and natural sciences. It begins with stimulating their interest in the field and ends up with making them become young specialists.

In this context, the process of mastering new knowledge is viewed as a continuous nonlinear change in the competence of the trainee, characterizing the qualitative transition from one level of competence to another [5].

The main problems that could be solved thanks to emerging of such an integrated educational environment deal with:

- the need to ensure the interaction of the developed educational environment with other non-governmental, legal and other institutions of the society;
- the need of infrastructure support for the interaction of the subsystems of the educational environment itself.

Ensuring interaction of the developed educational environment with other non-governmental, legal and other institutions of society [2]:

Administrative and economic issues:

- organization of legal and financial interaction with authorities, search for sources of co-financing;
- activities aimed to select the "territorial base" of training events;
- organization of administrative, financial, legal support for ongoing training activities.

Personnel issues:

- Top management: creation of an educational structure – the training administration, selection of the leading teachers (instructors), interaction with the leadership of the leading universities in the region, Russia and foreign countries, organization of internships and master classes for leading teachers.
- Staff: selection and training of personnel responsible for organizing and holding of cultural, entertainment and socially significant events with students (when implementing the training in the format of a children camp – creating uniform requirements and rules for organizing intra-group work, selection and training of instructors of primary level, elaborating rules for cultural and entertainment sphere.

Organizational and training:

- development of the structure of the educational process;
- logistics and facilities for laboratory workshops, providing measures to ensure high safety level within training sessions;
- elaborating of internal regulations (when implementing the training in the format of a children camp).

Ensuring interaction between the subsystems of the educational environment [2]:

1. Organizational:

- Solution of organizational and territorial problems connected with joint use of territorial resources of educational platforms. At the same time, by optimizing the territorial, administrative, and specific human resources, it is possible to reduce the cost of participation in educational programmes, which allows expanding the range of social coverage in the region.
- Ensuring socially responsible behavior of existing and newly created educational centers in the region (technological platforms, hobby groups, etc.).
- Ensuring interaction with regional resource centers to support educational programmes as a possible way to solve personnel, territorial, information and other tasks related to the implementation of interregional projects.

2. Information:

- Creation of a regional information portal to support the activities of educational platforms relating to formation of a knowledge base (development of programmes, teaching aids and methodological recommendations), interaction management (including various joint events: conferences, meetings, academic competition).

3. Scientific and educational:

- Implementation of relay training is now one of the most promising directions that allow combining the harmonious development of the trainee, the rationality and predictability of the training centers activities. The goal of forming a "big" project is to attract NGOs (and not just regional ones) with a different focus of training in a single educational process. The most promising, from the standpoint of a "big" project, are educational tourism projects.

4. Financial, economic and logistical support:

- Participation in federal and regional target programmes.
- Financial support for regional training centers.
- Creation of a basic technological platform – educational, laboratory and other technical support of educational projects.
- In framework of an integrated educational environment, the activities of regional NGOs can be consolidated in order to assure their participation in interregional projects. Such activities of the Center are considered as a tool of the "social elevator" for gifted children and talented teachers.

5. Testing and measuring:

- Development and implementation of a unified system of rating control - the implementation of a rating system for assessing the activities of educational platforms will reduce the impact and / or exclude the possibility of dishonest work and improve the status of effective organizations. Rating evaluation is mainly aimed at informing potential participants of educational projects, but it can also be considered as one of the criteria for evaluating the effectiveness of educational programmes when assessing their applications for their financing.
- Implementation of a "feedback system" – a system of interaction with consumers of services of educational centers organized on the principle of "all services at one place". Organization of this work is aimed at prompt resolution of issues related to improper performance of one or another educational platform, as well as for accumulation of incoming recommendations and suggestions for optimizing the activities of educational centers and the implementation of educational programmes.

The programme of network interaction of educational institutions of the Volgograd region

Considering the system of additional education for children as the most flexible educational platform, which in fact is an innovative platform for working out effective educational models and promising technologies for the future, the project implemented in the Volgograd region is aimed at developing and improving the structure, information, personnel, material and other support for high-tech educational programme. It is designed to ensure advanced updating of the content in accordance with the strategic tasks of the country development.

The main applied areas of practical implementation of the proposed professionally oriented educational environment are:

- robotic drone devices and robotics;
- electronic and electrical devices;
- technical modeling and prototyping of technical devices;
- organization of regional competitions, exhibitions, meetings, conferences in the technical field.

Today these areas are the most demanding in terms of the required for their implementation technical, technological, information, human and other resources. The proposed directions are presented in the list of priority directions for the development of science and technology in the Russian Federation.

One of the main tasks in the implementation of this project is the formation of the condition for the effective use of the infrastructural educational resources of its participants. The solution of this problem is seen in the formation of an integral system of an educational elevator capable of supporting the steady interest of schoolchildren in the field of technical sciences and research, forming creative teams at the level of primary sites, which are subsequently involved in regional educational programmes and competitive activities implemented jointly with the flagship university in Volgograd region – Volgograd State Technical University and Volgograd State Medical University.

In this regard, a pilot project which was launched and implemented during the 2015/16 academic year, was the inter-university educational project "Medical measuring systems and robotics" (fig. 1.).

Its participants are schoolchildren of the 6^{th} and 9^{th} grades of Volgograd secondary schools, mastered the theoretical foundations of electrical engineering and electronics, as well as the physiology of biological objects, and acquired skills in the development and manufacture of printed circuit boards for electronic devices.

Fig. 1. Regional competition of projects in children's technical creativity for students and schoolchildren in Volgograd region "Robotics and radio electronics for health, biotechnology and pharmaceutics".

The Faculty of Pre-University Training of Volgograd State Technical University took part in this project together with Volgograd State Medical University (VolgSMU), represented by the Department of Bio-technical Systems and Technologies and the Department of Clinical Pharmacology and Intensive Therapy with courses of Clinical Pharmacology, Clinical Allergology, as well as Volgograd Center for Children's Technical Creativity and Children and Youth Center of Volgograd. The project was launched, also thanks to assistance of the Interregional non-governmental organization "Association of Clinical Pharmacologists".

This project has found its continuation in the implementation of the educational programme within summer regional camp for gifted high school students "Integral".

At the moment, the structure of the project has been significantly expanded due to the participation of regional educational platforms.

The result of the pilot project of the integrated educational environment in the field of medical measuring systems and robotics was the regional competition of projects in children's technical creativity for schoolchildren of Volgograd region "Robotics and radio electronics for health, biotechnology and pharmaceutics".

Expected performance indicators of the professionally oriented educational environment

The main results of the programme implementation are:

1. Development of the structure of network interaction and proposals on the administrative regulation of the primary educational areas of children's technical creativity in the region in the development and implementation of programmes for children's technical creativity.

1.1. Indicator: number of educational platforms – participants in the programme implementation of a professionally oriented educational environment supporting the development of children's technical creativity based on the network integration of the infrastructure resources of educational institutions and full coverage of Volgograd region by the programme.

2. Increase in the level of popularization of additional general education programmes in the technical field.

2.1. Indicator: number of students taking part in additional general education programmes focused on the development of children's technical creativity.

2.2. Indicator: number of students participating in additional general educational programmes of children's technical creativity who have chosen technical directions of training in higher educational institutions of Volgograd region and Russian Federation to continue their educational trajectory.

2.3. Indicator: number of students participating in the field-oriented regional camp for gifted high school students "Integral", who selected as priority educational programmes of the camp "Integral" in the field of physics, mathematics and natural sciences.

3. Development of the structure of network interaction and administrative rules regulating primary regional educational platforms for children's technical creativity relating to the development and implementation of competitions in the field of technical sciences and research.

3.1. Indicator: number of competitions.

3.2. Indicator: number of students who took part in the competition.

4. Development and implementation of the basic measures for staff acquisition for additional general educational programmes of technical orientation and the system of professional development of pedagogical workers in the field of physics, mathematics, technical and natural sciences and pedagogical workers who mastered the teaching methodology in interdisciplinary fields.

4.1. Indicator: number of pedagogical workers retrained in the field of physics, mathematics, technical and natural sciences.

4.2. Indicator: share of pedagogical workers who completed advanced training programmes in teaching methodology in interdisciplinary fields and implemented this methodology in educational process.

4.3. Indicator: number of pedagogical workers who took part in conferences, scientific and methodological seminars and competitions within additional general educational programmes in the field of technical sciences and research.

5. Development of information educational resource for support and remote assistance of additional general educational programmes in the field of technical sciences and research.

5.1. Indicator: number of educational content units offered on the resource.

5.2. Indicator: number of resource users.

5.3. Indicator: number of correspondence educational programmes available on the resource.

REFERENCES

1. On the popularization of blue-collar jobs and engineering professions [Electronic resource] // Government of Russia: website. – M., 2016. – URL: http://government.ru/docs/17129, free. – Tit. from the screen (usage date: 17.07.2016).
2. Isaev, A.V. Development of regional resource centers to support socially oriented non-profit organizations: problems and prospects // Vestnik NGUEU. – 2013. – No. 4. – pp. 352-363.
3. On the approval of the long-term regional targeted programme "Support to socially oriented non-profit organizations of Volgograd region for 2013-2015" [Electronic resource]: Government resolution Volgograd. reg. from 29 Dec. 2012 No. 649-p. – URL: http://ag.volganet.ru/export/sites/ag/agavo/folder_4/folder_3/Post649poSONKO.pdf, free. – Tit. from the screen (usage date: 30.07.2013).
4. Isaev, A.V. Automated system of support and management of an individualized educational trajectory. Theoretical basis: monography. / A.V. Isaev. – Odessa: Kuprienko S.V., 2012. – 117 p.
5. Isaev, A.V. Self-directed training of students in higher education: theoretical aspects: monography. / A.V. Isaev; Ed. T.F. Sergeeva. – Rostov-on-Don: RostIzdat, 2012. – 170 p.


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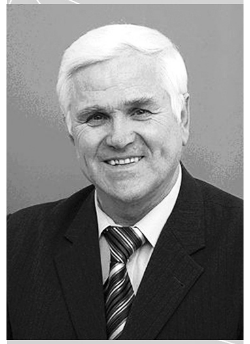
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Modular Training of Specialists on Innovative Design in Mechanical Engineering

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The basic concepts of modular training of specialists on innovative design in mechanical engineering are presented in the article. The concept of continuous innovative training of specialists on the example of the "Innovatics" module is illustrated. The description of educational and methodical teaching materials for "Innovatics" module is provided as an option for realization of electronic and distant teaching and learning methods.

Key words: innovative activity, innovatics, educational technologies, module, continuous innovative training, educational and methodical teaching materials.

INTRODUCTION

Topicality, aims, objectives and priorities of innovative activity in Russia are set by the requirements of:

- Russian Federation Federal Laws (Federal Law On Science and Governmental Policy on Science and Technology No. 127 – FZ; Federal Law on Education in Russian Federation No. 273-FZ of 29 December 2012; Federal Law On Industrial Policy in Russian Federation No. 488 – FZ of 31December 2014);
- Russian Federation Government Decrees («On Strategy of Innovative Development of the Russian Federation until 2020» of 8 December 2011 No. 2227-p; «On State Support of Innovative Infrastructure Development in Federal Educational Institutions of Higher Professional Education» of 9 April 2010 No. 219);
- Federal Targeted Programmes (Russian Federation Government Resolution No. 97 of 23 May 2015 on Education Development Federal Targeted Programme for 2016 – 2020).

Proposition of the legislative acts mentioned above is triggered by the fact that in the context of a global trend of economic development of developed countries the development tendencies are focused on the technological shifts by means of innovative activity [1, pp. 85-91]:

- the significance of the technological progress among the factors influencing the increase of the USA's GDP had been around 28% (research from 1929 to 1982, [Campbell]);
- the research conducted in the USA after the World War II indicated that 43% of GDP's growth is triggered by inventiveness, technological progress, education and other drivers [Samuelson];
- at the end of the XXth century a Nobel Prize laureate R. Solow had identified that the value of technological shifts (87,5 %) for the economic development of the USA is significantly higher than capital and labor (12,5%) [Solow, Sakhal].

In order to bring to action the requirements towards engineering education and specialists' training stated-above higher education schools have to gain a wide expertize in innovative training of bachelors, masters and qualified specialists based on the use of topnotch achievements of science and technology [2, pp. 29-42]. This issue is discussed further.

1. INNOVATICS – A NEW COURSE FOR ENGINEERING EDUCATION

Leading universities of the world have formulated modules of innovative study programmes as following:

- Innovations (600 h, Stanford University, USA);
- Innovations and Entrepreneurship (480 h, Harvard University, USA);
- Innovations (200 h, Aston University, Birmingham, Great Britain) and others.

The aims and core contents of the "Innovations" module (developed by Dr. Mike Kennard, Aston University, Birmingham, Great Britain) are defined as follows:

1. Acquisition of key theoretical ideas on innovations and innovative activity in industry for assuring competitiveness and prosperity of enterprises.
2. Comparison of scientific research and innovative theories for management of enterprises on practice.
3. Efficiency assessment of innovative strategies for various organizations.
4. Management of innovations.

The contents of this module reflect ideas of strategic management of innovations: processes from creation, development, introduction of new ideas, technologies, products and services to commercialization of new high and critical (key, creative) technologies. "Innovatics" module and theoretical approach to innovations are connected with practice and focus on approaches for development and transformation of innovations for commercial market. Ideas and structure applied for this module of disciplines are completed with topical research on innovations introduced in British enterprises and foreign organizations of international scale. Vital components of innovative training modules at leading foreign universities are the following additions to the typical forms of modules (that use ordinary lectures, practical and laboratory classes, tests, self-training and course project work):

1. Distant learning;
2. Decomposition of modules of innovation-focused disciplines;
3. On-line lectures;
4. Venture programmes for incubation;
5. Group presentations;
6. Investment games.

Similar developments have been introduced at Russian higher education schools [2, pp. 15-28]. The concept of development and realization of innovative educational programmes at Ufa State Aviation Technical University (among 7 leading universities of Russia since 2014) is based on a systemic technical combination of the original innovative technologies mentioned above:

1. Implementation of innovative pedagogy focused on employers;
2. Driver for development of innovative technics, technology and economy of a region;
3. System integrator of best components of innovative pedagogy and innovative activity of leading universities in the interest of innovatively active enterprises.

2. SINERGY EFFECT OF SPECIALISTS' CONTINUOUS INNOVATIVE TRAINING

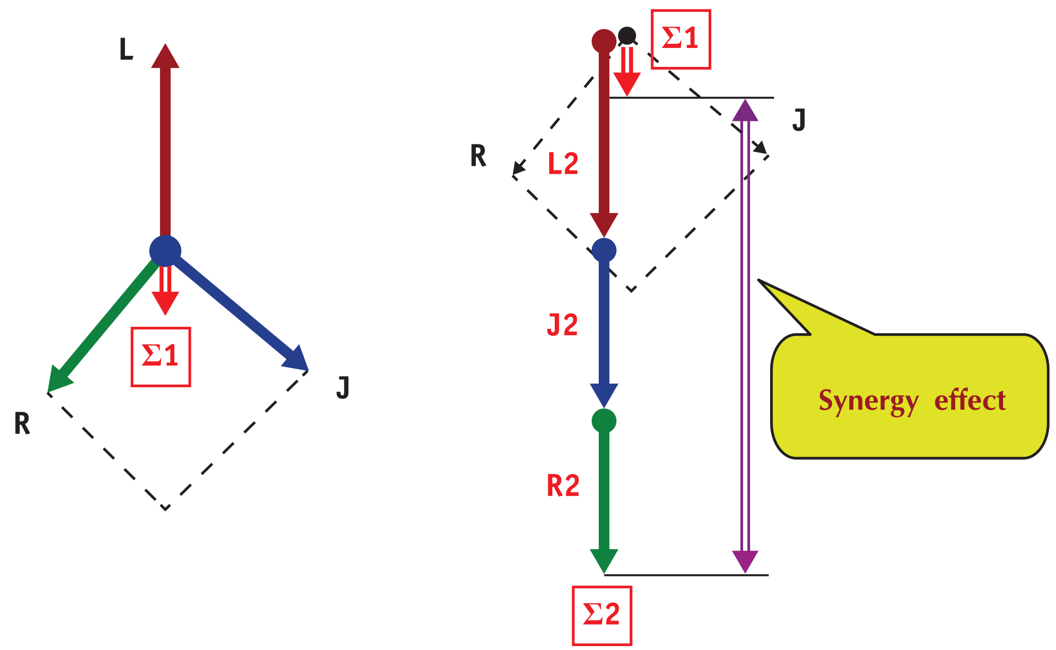
Introduction of programmes for continuous innovative training of specialists, bachelors, and masters, which is carried out at Ufa State Aviation Technical University, ensures synergy effect (synergy, synergism – from Greek "Synergism" – working together). The law of synergy is worded as follow: "A sum of the qualities of a whole is greater than an arithmetic sum of the qualities of its parts".

Synergy effect appears in different organizational systems, including realization of continuous innovative training of specialists (fig. 1, table 1) in connection with problem-oriented educational programmes of scientific courses focused on innovative activity in training engineering workforce [3, pp. 40-63].

The reported example of Ufa State Aviation Technical University allows taking engineers' innovative training to Stanford and Harvard levels (table 1).

Synergy effect of the continuous innovative programme for training specialists appears not so much due to the increase of course hours on "Innovatics" course (it is rather short and lasts for only 72 hours of theoretical training; table 1), but rather due to the introduction of innovation-oriented courses (table 1) and specific units of other disciplines that assure a high-level scientific and technical innovative design.

Fig. 1. Scheme of synergy effect from goal orientation and project organization of staff (enterprises, institutions)



Version I *Version II*

For instance, specific innovative units of disciplines on natural sciences may include learning the following issues:

Higher Mathematics:

1. Analysis of sigmoidal patterns and relationships, including Fermi equations.
2. Analysis of logistic and bylogistic laws.
3. Analysis of mathematical models of Fisher-Pry, Gompertz, Morris, Sakhal, Kamenev, Pearl.
4. Analysis of Parzen's cross-covariance functions.
5. Fourier analysis.
6. Analysis of Volterra integral equations and Verhulst differential equations.

Physics:

1. Schemes of physical operation principles of critical technologies.
2. Research of physical operations.
3. Physical effects of critical technologies (for instance, acousto-optic effect, electro-hydraulic effect, acousto-magnito-electric effect, autoelectronic emission, adiabatic demagnetization, magnetic reversal).

Information technologies:

1. High-end computing systems.
2. Quantum computers.
3. Computer simulation.
4. Artificial intelligence.
5. 3D simulation of production systems in virtual reality classes.
6. Basics of information technologies in CAD/CAM/CAE/CAPP/PDM/CALS-systems.

Economics:

1. Consistent patterns of innovative economics.
2. Innovations and capital market.
3. Crediting of innovative processes.
4. Banking technologies for investment and innovative activities.
5. Investment project development, business-planning, etc.

Table 1. Example of "Innovatics" module design for training specialists of mechanical engineering major

№	Disciplines	Hours	Bachelor programme, hours								Master programme, hour				PhD	
			Semester	3	4	5	6	7	8		9	10	11	12	13	14
1	Innovatics	72		72								*elective course				
2	Gas Turbine Engines of Next Generation*	72			72											
3	Nano-techno-logies and Nanoma-terials for Aviation*	72				72										
4	Patent Practice	72					72									
5	Innovative Processes in Mechanical Engineering	108						108								
6	Technical Production Support Work	216						216								
7	Technical Re-tooling of Machinery Production	144							144							
8	High-End Technology in Gas Turbine Engine Production*	72							72	Internship Thesis						
	Over whole module:	828		72	72	72	72	324	216							

№	Disciplines	Hours	Bachelor programme, hours								Master programme, hour				PhD	
			Semester	3	4	5	6	7	8		9	10	11	12	13	14
1	Prospective Materials for Aviation Technology*	144		*elective course*							144					
2	Innovative Technological Design	144										144				
3	Design of Digital Production	144										144	Internship	Thesis		
	Over whole module:	432									144	288				
1	Innovative Technologies and Technical Re-tooling of Production	207													99	108
	Over whole module:	207													99	108

3. MODULAR, NETWORK, ELECTRONIC AND DISTANT LEARNING IN THE FILED OF INNOVATICS

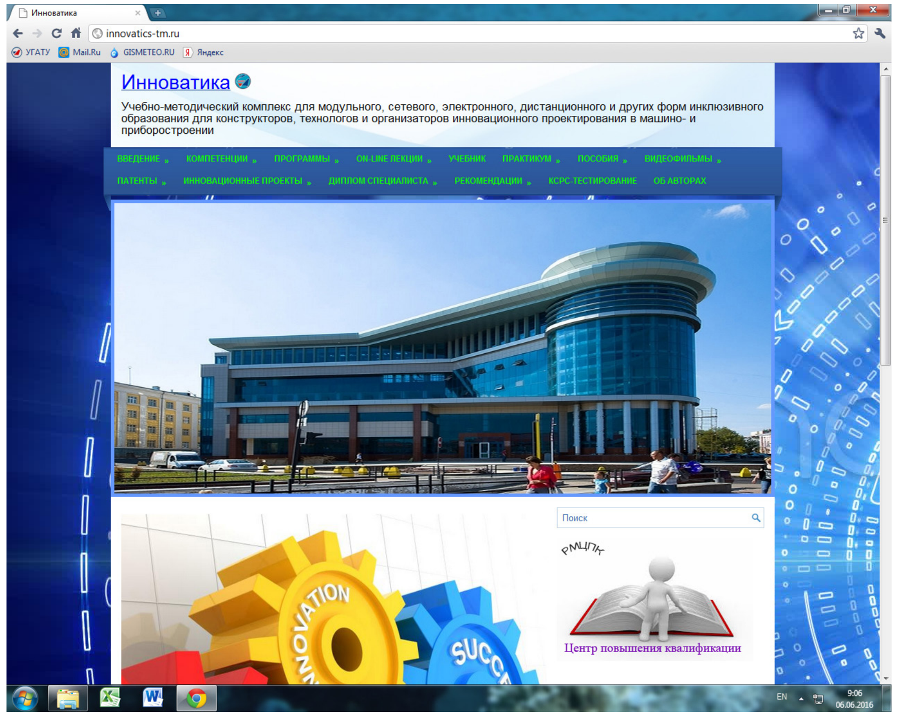
As has been stated above, in accordance with the requirements of the Federal Law on Education in Russian Federation No. 273-FZ of 29 December 2012, the most important study programmes and teaching and learning methods are modular and network programmes, electronic and distant teaching and learning methods.

In this context the "Innovatics" module (www.innovatics-tm.ru) and programmes for continuous innovative training for industry are currently equipped with study and guidance materials available through the Internet (fig. 2).

Study and guidance materials database includes the following electronic modules:

- Competence-based models and study programmes.
- Textbooks, workbooks, laboratory practicums.
- Lectures for students and public speeches of leading specialists.
- Monographs published in Russia and abroad.
- Automated system of scientific research of high and critical technologies, e-databases for innovative design.
- Videos on high technologies of best mechanical factories of the world.
- Regulatory documents and approaches.
- Patents and unified technologies for innovative design.
- Examples of innovative projects.
- Examples of Bachelor, Master and PhD theses in the field of innovations.

Fig. 2. Front-page of the "Innovatics" module study and guidance materials database



- References and reading materials, foreign publications, glossary on innovations.
- System for knowledge assessment (testing) via the Internet.

The "Innovatics" module website provides direct access to profile websites of world leading universities.

CONCLUSIONS

As practice shows, the methods enlisted above provide opportunities for trained specialists focused on innovative activities to:

1. Significantly shorten time for development of new technologies and launching them into production.

2. Assure competitiveness of engineering products and enterprises by means of innovative design, development and introduction of technological innovations.

3. Increase technological level and efficiency of mechanical manufacturing up to the level of best national and foreign counterparts by means of introducing unique system of technical (technological) re-tooling of production executed in the process of innovative activity at aviation enterprises.

Introduction of the proposed system of continuous technological reconstruction to one of the enterprises has practically led to a fast-track launching to production of more than 50 new products of aviation technology, as well as to doubling of the production volume on the same premises and with the same workforce [1, pp. 338-349] and with minimum loans.

Introduction of the study and guidance materials database to the continuous innovative training of specialists, bachelors and masters within the study process fulfills the requirements of:

- The Federal Law on Education in Russian Federation No. 273-FZ of 29 December 2012.

- International ECTS requirements (*ECTS and Diploma Supplement – European Community Course Credit Transfer Systems*).

Authors of the proposed module and study and guidance materials database on "Innovatics" for the realization of study programmes in modular and network forms, and of e-learning and distant learning are confident that the disclosed method for continuous innovative training of specialists and the "Innovatics" module in case of their wide-spread introduction could assure the enhancement of engineering training at HEIs up to the level of the leading universities of the world.

REFERENCES

1. Selivanov S.G. Innovatika : uchebnik dlya vuzov [Innovatics: university textbook] / S.G. Selivanov, M.B. Guzairov, A.A. Kutin. – 3rd edition. – Moscow: Mashinostroenie, 2013. – 640 p.
2 Selivanov S.G. Innovatika I innovatsionnoe proektirovanie v mashinostroenii: praktikum [Innovatics and Innovative Design in Mechanical Engineering : Practicum] / S.G. Selivanov, N.K. Krioni, S.N. Poezjalova – Moscow: Mashinostroenie, 2013. – 770 p.
3 Selivanov S.G. Sistemotekhnika innovatsionnoi podgotovki proizvodstva v mashinostroenii [System Engineering of Innovative Pre-Production in Machine-Building] / S.G. Selivanov, M.B. Guzairov – Moscow: Mashinostroenie, 2013. – 568 p.

UDC 37.031.4

Concept of Subject Area "Technology" as a Way to Modernize Learning Content and Methods at Modern School

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The paper presents the main idea of "Technology" concept developed by the team in Russian Academy of Education. The concept distinguishes the basis and the main areas of learning content and methodical modernization in technology education at Russian schools.

Key words: technology education, design and technological culture, subject area "Technology", learning content, learning methods, engineering and technology training.

Problem statement

Recently, teaching communities and professional associations have been actively debating the need to modernize the learning content and teaching methods in the subject area "Technology".

The post-industrial society is in demand for highly-qualified specialists who are ready to live and work with ever-changing technologies and technological systems. The inconsistency between this demand and the level of school leavers' knowledge has become the reason for sharp critics of modern technology education at Russian schools.

Engineering competencies, systems thinking and creativity, communication skills, ability to analyze scientific and technical data, work with technical documents are the basic personal attributes that are in demand in the modern society. It is these attributes that shape the technological culture and should be developed within the subject area "Technology".

In the context of high-tech manufacturing and breakthrough technologies, the level of technological culture defines human resources of the economy and production of the country, its competitiveness on the global market, intellectualization of human capital and knowledge-intensive activities, as well as ensures security and culture of manufacture and other technological processes.

In foreign countries, the education system, in which the subject area "Technology" plays a significant role both due to its importance and high volume of content in the basic education, allows educators to shape strong human resources for further professional education and, thus, ensure competitiveness of manufacture on the global market. Great Britain, France, Germany, USA, Israel, South Korea, China, etc. are among these countries.

Worldwide, the competitiveness of the education system that is a key condition for sustainable development of the national economy, manufacture, defense capacity and national security is ensured by the following: 1) improvement of pupils' academic training, especially in the field of natural sciences and mathematics; 2) enhancement of science and technology literacy (culture) of school leavers, which would enable them not only to use effectively up-to-date technologies at the personal level, but also to succeed in acquisition of modern technological systems and procedures at the professional level, i.e. design and management of machines and technologies. The second trend is in its broader sense technological (polytechnic) education of young people, one of the components of which is the subject area "Technology" taught at school.

Relevance and grounds of the concept

At the instruction of the President of the Russian Federation (RF) and resolving the tasks of the Federal target programme "Education development from 2015 until 2020" (objective 2 – development of modern methods and technologies for secondary education), the Russian Academy of Science has developed the Concept of the subject area "Technology" and initiated the expert seminar. The proposed concept is currently being debated by teaching and academic communities.

The concept rests on the following ideas: shaping youth technological culture, preparing young people for work and further education, including development of such attributes as willingness to work and respect for work; involvement of pupils into all types of organizational culture (traditional, corporate-handcrafted, professional, design-engineering) with the corresponding technologies and social roles; diversity of engineering training (with regard to regional peculiarities); acquiring competency in universal activities (design, research, management); identification of "through study paths" in engineering training, which would explain the logics of studying this or that technology of material processing, energy, and information; assistance in entering labor market, first experience such social roles as employer, businessman, service technician, designer, technician, manager, and others relating to acquisition of knowledge about engineering and technology in the course of professional activity [1].

Today, the subject area "Technology" is referred to:

- *school subject* (studied by all pupils starting from 1 to 11 grades. As a learning outcome, pupils gain understanding of engineering and technology, get familiar with the world of engineering profession and labor, achieve meta-subject outcomes by the example of practical activity);
- *specialized subject* (for various specializations in 10-11 grades at school. It is aimed at studying such technologies and technical systems which are specific for the chosen occupation);
- *social and engineering-manufacturing internship* (it is designed to prepare pupils for actual workplace, professional activity under the conditions of industrial, social, and volunteer practice).

Within the learning content, the subject area "Technology" serves as a basic integration mechanism that allows pupils to synthesize knowledge of natural science, technology, business, humanitarian during design and engineering activities. Additionally, it enables them to apply this knowledge appropriately in various fields of human activity, which contributes to assuring pragmatic (applied) character of secondary education.

The learning outcomes of the subject area "Technology" are designed so that to ensure such level of a personal technological culture that is required for sustainable development of society, national economy and manufacture. This level implies [2]:

- ability to comprehend, apply, control, enhance and evaluate technologies in the process of modification;
- acquisition of universal competencies within such activities as design, research, and management;
- ability to address the contradictions and reveal the problems in practice by means of adequately selected and applied technologies;
- commitment to creative and untraditional actions, willingness to develop new products, new mode of action, new mechanism to act on the subject of labor, etc.;
- conscious choice of future profession by trying various occupations in the course of secondary education;
- commitment to work and constant self-development that implies acquisition of new knowledge, skills, and competencies during engineering activity;
- flexibility and ability to adapt to the ever-changing conditions in uncertain situations.

Main principles of the Concept

The main objectives of technological education at secondary school are to foster pupils to acquire, transmit and change technological culture.

In addition, technological education may also serve both as a tool of socialization and personality development, and a method to forge the technological culture.

Being a component of culture as a whole, technological culture is regarded as prerequisite and result of the technological education. Despite the fact that the notion of technological culture was proved as a scientific term at the end of 20th century, its meaning remains constant and it includes [3]:

1) a set of technical tools, technologies, units, management and control systems, hardware and software packages and etc. designed during modernization (objective results of human activity);

2) subjective human forces and abilities applied during modernization: knowledge, competencies, abilities, profession-related personal attributes, etc.

Being a reflection of objective and subjective results of human activity, the technological culture changes due to scientific and technical progress, implementation of new technologies, emergence of new problems in machine maintenance and control. Each era is characterized by its own set of components which comprise the technological culture, i.e. technological environment. Thus, technological environment can be termed as a unity of objectives and subjective results of human activity in a certain historical moment, a moment of studying relationship between personality and the artificial world.

The technological environment determines the conditions and provides the possibility for modernization. Correspondingly, it defines the peculiarities of technological culture development among pupils, i.e. it influences the developed educational environment. In this regard, the main goal of human education is to harmonize the requirements of the technological environment with the level of person's training, i.e. his/her readiness for modernization within this environment.

Today, the technological (engineering) education has entered a new stage in its development and is trying to resolve the issues of revising the content and learning outcomes of "Technology" curriculum taught at schools. This issues are worldwide discussed by educational communities.

One of the basic principles that underpins the technological (engineering) education is the concept of changing forms of human activity in this or that type of society (A.M. Novikov). The concept outlines four types of organizational culture of society – traditional, corporate-handcrafted, professional (scientific), design-engineering [4], which directly refer to labor and manufacturing processes at a certain development stage of machinery and technology, science, and social relations.

The design-engineering organization of modern postindustrial society rests on the idea of implementing various programmes and projects into practice via technologies of all kinds and with due regard to the factors that may influence implementation of these projects (economic, staff-related, facilities-related, environmental, etc.). It is due to this fact a separate branch of management – risk management – has budded off, and various types of project-oriented learning have gained particular popularity.

Within the proposed concept of the subject area "Technology", the idea that a pupil should get familiar with the design-engineering organizational culture and up-to-date technologies, which is reflected in the corresponding learning outcomes and programme content, is not sufficient. Additionally, pupils should gain knowledge of all types of organizational culture existing alongside traditional technologies (people have still used knifes, axes, hammers, people have still tied sailor's knots) and allow developing fine motor skills, coordination, practical skills in using manual (as well as electrical) instruments and shaping labor culture and corresponding personal attributes.

In the course of modernization, the visions for materials, tools, technological processes, peculiarities of labor organization, relating both to the current technological environment and that of the past and future, are shaped. These visions define the model or the landscape of the artificial world where certain regularities, principles, theories, and relations are in force [5]. The analysis of modernization and technological knowledge accumulated by humanity through the lens of goals and objectives of secondary education allows formulating fundamentals that should be studied at school regardless subject, module, and peculiarities of technological (engineering) training.

Such fundamental notions that define the core of technological (engineering) education are as follows:

1. Material.
2. Energy.
3. Information.
4. Technical systems.
5. Technology. Technological processes.
6. Design.
7. Research (structure, functions, methods).
8. Organization and management.
9. Relations (person-machinery, person-technology, machinery-technology, etc.).
10. Economics and ecology.
11. The past and future of technology (history).
12. Innovative creative work and invention activities.

The subject area "Technology" is the only mechanism to shape the technological culture, i.e. one of the components of pupils' general education and personal culture. In the context of the Federal state education standard, the social, personal and cognitive development of pupils within the subject area "Technology" is achieved during:

- acquisition of scientific (theoretical) and technological knowledge in the course of practice-oriented and engineering activities;
- analysis of the world of machinery and technologies, examination of material properties and characteristics, investigation of opportunities to control technical systems and technological processes;
- study of traditions of peoples that inhabit Russia, cultural and national peculiarities of handicraft and products of decorative and applied arts, mastering various types of material art processing and industrial design;
- self-determination of pupils in workplace related activities, from workspace organization up to identification of career preferences, choice of career path and personal growth.

The subject area "Technology" is comprised of a number of subjects and modules (invariable and variable) aimed at achieving the desired personal, subject-related and meta-subject outcomes on the basis of practice-oriented activities of pupils.

The subjects make up the core of technological (engineering) training of pupils. They are designed to familiarize pupils with the fundamentals of engineering education both at general and specialized levels, as well as via practice-oriented classes and internship.

There are the following subjects (fig. 1.):

- "Handicraft" as a school subject (from 1st to 9th grades).
- "Technical drawing and design engineering" (from 7th to 9th grades).
- "Introduction into professional activity" as a specialized technical subject (according to the specialization in 10th-11th grades).
- "Internship" (from 7th to 10th grades).

Modules are designated to familiarize pupils with various aspects of technological (engineering) training. They are basically variable and are taught within all core subjects:

- Scientific and technical information and technical documentation.
- Technological systems and processes.
- Analysis of materials and structure;
- Design and modeling.
- Methods to solve design and project problems.
- High technologies.
- Technology management and control.
- Design and project fulfilment.

The modules are designed in the way so that they have the same learning content, learning outcomes, teaching aids, facilities, and requirements for teacher's qualification.

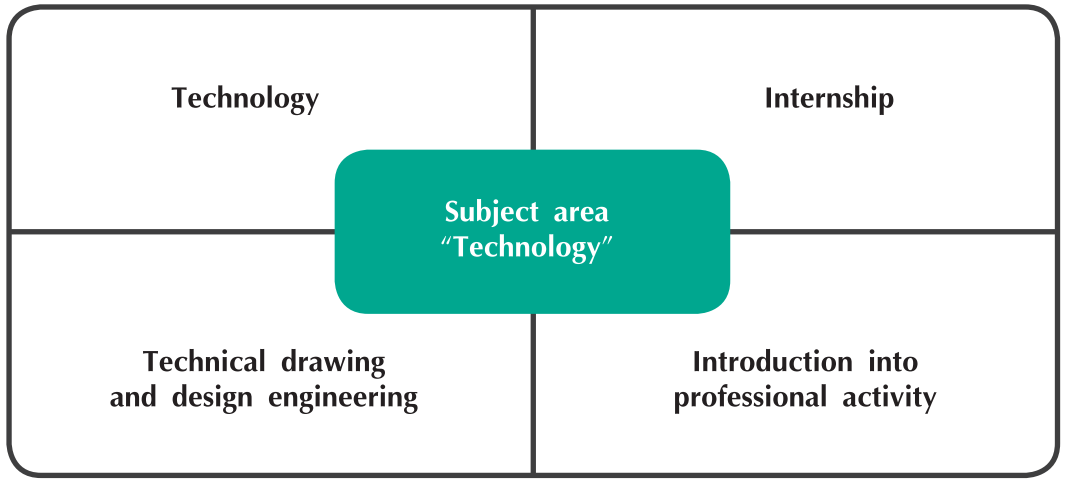
The subjects and modules of the subject area "Technology" are taught both during class hours and outside the core schedule on the grounds of the basic education programme and its variable components. The model to implement the subject area "Technology" is defined in accordance with the teaching standards of a region.

The variable modules of the technological (engineering) education can be developed within three areas of modern industry – engineering, agro-technological, service-technological (sphere of services). Additionally, the variable modules may imply education by means of integrative environment (for example, robotics technology, modern energetics, transport systems and machinery). The variable modules account for not more than 30 % from the content of the education programme in "Technology". Extra hours can be received due to outside activities and individual planning.

The variable modules of technological (engineering) education can be implemented not only be means of regional education development programmes, including that of technological education development (both at the school level and regional one – long-life technological education in a region), but also due to intensive cooperation with social partners, local industries, representatives of small- and medium-size business, innovation centers, and professional educational establishments.

The role of social partners is to generate the demand for this or that module, define the trajectory of pupils' technological (engineering) training, provide access to their facilities and industrial sites, participate in educational process as experts, masters,

Fig. 1. Structure of the subject area "Technology"



project supervisors who would formulate workplace-related design and technological tasks (cases, projects) and take part in development of joint research projects, industrial initiatives and startups.

Secondary schools should promote active participation of pupils in various competitions and contests in engineering and art. However, the basic priority for pupils is to take part in All-Russian Pupil Olympiad in Technology JuniorSkills, regional youth contests and projects aimed at developing design art, project thinking, and entrepreneurial skills.

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REFERENCES

1. Oreshkina, A.K. [i dr.] Podhody k modernizacii soderzhaniju i tehnologij obuchenija v predmetnoj oblasti "Tehnologija" [Approaches to revicing content and teaching methods in the subject area "Technology"]. Shkola i proizvodstvo [School and industry]. 2016, no. 8, pp. 14–18. (In Russ., abstr. in Engl.).
2. Mahotin, D.A. Tehnologicheskaja gramotnost' obuchajushhihsja kak rezul'tat obshhego obrazovanija [Technological literacy of pupils as a result of secondary education]. Profil'naja shkola [Specialized school]. 2015, Vol. 3, no. 2, pp. 8–15. (In Russ., abstr. in Engl.).
3. Novikov, A.M. Postindustrial'noe obrazovanie [Postindustrial education]. Moscow: Egves, 2008. 136 p. (In Russ.).
4. Novikov, A.M. [i dr.] Metodologija: slovar' sistemy osnovnyh ponjatij [Methodology: dictionary of system basic notions]. Moscow: Librokom, 2013. pp. 110–113. (In Russ.).
5. Mahotin, D.A. [i dr.] Sovremennye podhody k razvitiju tehnologicheskogo obrazovanija v obshheobrazovatel'noj organizacii [Modern approaches to developing technological education at schools]. Mir nauki, kul'tury, obrazovanija [World of science, culture, education]. 2015, no. 4, pp. 65–68. (In Russ., abstr. in Engl.).

UDC 378.4, 372.862

Innovative Technology for Mass Training: Case Study of e-Course "Mechanical Engineering"

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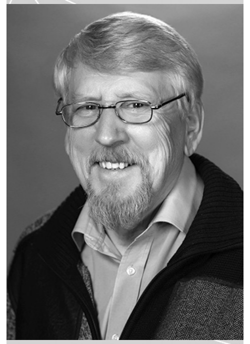


E.A. Mityushov

The paper describes a course "Mechanical engineering" set up on the National Open Education platform. The course has a well-balanced system of authors' solutions, special practice-oriented tasks that encourage students to learn and develop engineering thinking. The disguising features of the course are weekly-based structure that allows controlling students' independent work, a practical-cognitive module, and an interactive programming module.

Key words: e-course, open education, engineering thinking.

According to the current Federal Education Act [1], when implementing educational programmes the universities may use e-learning beyond the traditional educational technologies. The State Programme of the Russian Federation "Education Development" for 2013–2020 [2] has determined the priorities of the state policy in the higher education sector. Among the major priorities there are introduction of open learning; wide application of information-telecommunication technologies; ensuring information transparency of education system for the society; development of high-tech educational environment.

The technologies and priorities mentioned in the Act and described in the State Programme reflect the international trends of education development [3, 4]: mass character and internationalization which entails: changes in learning technologies taking into account modern engineering and social-humanitarian achievements; significant transformation of lecture-seminar learning model; wide use of on-line courses; implementation of active learning methods.

With the launch of the National Platform of Open Education openedu.ru there appears an opportunity for students to transfer credits supported by a certificate on the suggested on-line courses in Russian universities when learning programme of Bachelor's or Specialist's degree. The focus on engineering learning content is a path that the course authors have chosen. The authors did not only use technical potential of the National Platform at the most, but also changed the course content in many aspects due to its filling in with practice-oriented problems.

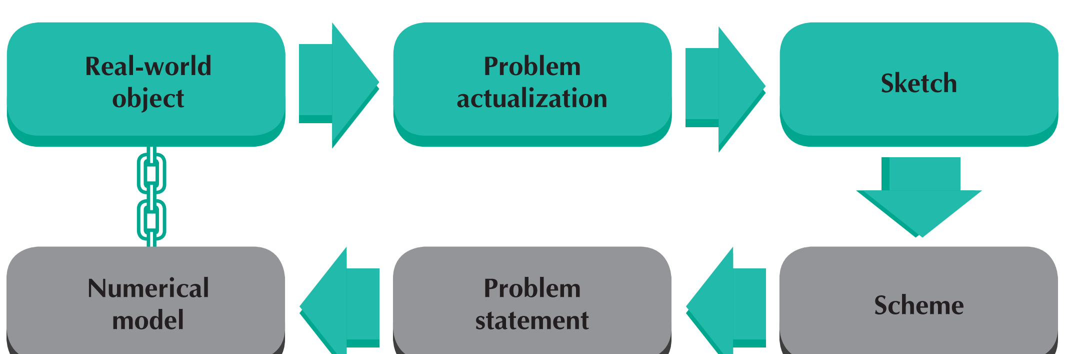
Designing the course to form the bases for engineering thinking, the task was set to motivate students to use all the variety of methodical innovations and potentials of information-telecommunication technologies. For this purpose, modern electron methodical content was developed in a wide range of information formats: lectures and examples of problem solutions accompanied by visual materials of actual process and phenomena; interactive learning manuals with comments of incorrect solutions; theoretical test questions and context problems on calculation of real constructions and mechanisms with a wide range of parameters; home assignments supported with stage-by-stage solution and stage-by-stage automated check; basic projects including several course sections. The pool of practice-oriented problems, tests, home assignments, basic projects with videos of real processes and phenomena, their sketches was formed. Multi-optional resource of testing and assessment materials was collected to perform weekly unbiased assessment of learning outcomes independently and automatically. Project-based technology was adjusted to e-learning using the basic project with implementing the authors' research results into learning activity including works of the course authors performed with students.

The concept of electron learning resource development on "Engineering mechanics" results from the existing problems in the sphere of engineering training, namely, the disbalance between stake-holders' demands and potential of traditional engineering staff training in universities that, in most cases, exists in implementing educational programmes based on the Federal State Standards of higher education. The need to confront those difficulties results in demand for the transfer from traditional education which can be compared to filling-in the repository with knowledge accompanied by a set of exercise on brain jogging towards active content interaction with the realities of today's world. Considerable progress towards the reforms of basic engineering education can be made under the condition of organic integration of best traditional practices with cognitive-applied methods widely using information-telecommunication technologies.

The reform concept of Bachelor and Specialist general engineering training chosen by the authors on the basis of their experience is focused on motivation of students' learning activity to train them both for studying the profession and self-education and self-development. The key authors' solutions are aimed at applied training to learn the world around, its spatial and quantitative relations.

A visual representation of cognitive-applied module connection with its traditional structure is given in fig. 1 showing students' learning activity in the training process. Following the traditional integrated unity of learning form and content, the additional cognitive-applied module allows a student to be involved in motivated active creative cognitive activity starting from basic training. In this case, students are to develop individual work skills to acquire knowledge using different information sources: traditional textbooks, electronic textbooks, Internet resources, mutual consultations, and teachers' consultations. The context problems included in the course allow transferring the real world processes and phenomena into numerical models with clear understanding of practice-oriented problem statement. The course problems (analysis of forces in bridge rods, jib crane construction, racers' and pilots' overloading, positioning of laser lathe knife with numerical programme control, etc.), and particularly individual tasks of basic project with the elements of real engineering

Fig 1. Traditional connections (grey) and new additional cognitive-applied module (green)



solutions provide harmonic continuous shift to the study of professional disciplines.

Apart from traditional teaching, the section of fundamental training is added with a module shown in fig. 2 to make it more practice-oriented.

The potential of inversion is applied as a form of theory delivery. Fundamental knowledge is either visualized by illustrating real world processes and phenomena or illustration is followed by theory delivery. Change in conception of mechanics teaching contributes to the increase in efficiency of learning outcome achievement.

"Engineering Mechanics" course is aimed at implementing educational programmes for the profile of "Engineering and technical sciences". The course contains structured presentation of main concepts and principles of mechanics, description of numerical modelling techniques of engineering constructions and typical models and mechanisms. The course content is focused on students' preparation for learning other disciplines of the education programme profile. The course considers equilibrium and motion of mechanical systems in combination with mathematical rigor based on key concepts and theorems of mechanics. Traditional theory is accompanied by analysis of only practice-oriented problems with construction of 2D and 3D analytical models.

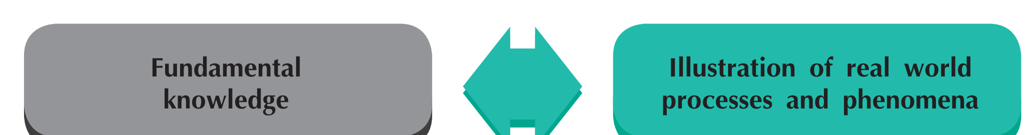
After learning this course a student will be able to: describe equilibrium and motion of a single mass point, system of mass points, and a rigid body system using the key concepts, laws, and theorems of mechanics; construct 2D and 3D analytical models describing the equilibrium and movement of typical engineering bodies; select a numerical model to determine geometrical parameters and power loads in the problems of engineering body's equilibrium and motion; study motion of parts in typical machines and mechanisms; determine kinematic characteristics of parts in the typical machines and mechanisms in their motion; apply mathematical operations in generation and solution of equations describing equilibrium and motion of engineering bodies in terms of designed mathematical models.

The methodical innovations are based on the teaching experience in one of the leading universities, namely, Ural Federal University named after the first President of Russia B.N. Yeltsin. In 2006, the authors of the course published the textbook [5] approved by the RF Ministry of Education and Science. In 2011 the second edition of the textbook was issued for Bachelor's syllabuses [6], in 2012 – book of problems [7]. The authors have upgrade certificates including those of on-line courses on mathematics, physics, and mechanics on Coursera international platform. The authors continue their professional development introducing the concepts of modern engineering education in learning process, for example, Conceive – Design – Implement – Operate (CDIO). The results of authors' practical research are aimed at increasing the efficiency of learning in the sphere of engineering education.

The technological means of increasing the learning efficiency are provided by maximal using of tools on openedu.ru platform and potential for its filling-in with original software (interactive problems) on "Engineering mechanics" course taking into account its specificity.

The successful course completion is ensured by regularity of students' work and their active participation in on-line

Fig 2. Traditional forms of learning (grey) and new additional cognitive-applied module (green)



discussion of specific challenges with each other and with teachers.

When designing the on-line course on "Engineering mechanics", the original authors' techniques aimed at potential of openedu.ru platform were implemented in learning process.

To make an emphasis on the key learning concepts, differentiate learning process in terms of students' level of skills, motivate students for regular learning, the learning material is equally divided into chronological parts (weeks) according to its workload and time consumption of doing learning and monitoring tasks. There is a uniform delivery of learning material and students' study time per a week cycle.

Motivation for cognitive-applied learning activity is supported by the content of theoretical learning material with the illustrations of purely practice-oriented content presented by video of real processes, animations, photos, and sketches of engineering bodies that precede the problem statement. The research problem parameterization is carried out with specific consideration of the range of possible changes in geometrical, physical, constructional, and engineering characteristics of real engineering objects and processes with their participation. This approach provides the shift in students' minds from solution templates and fragmented information towards integrated perception of real problems with the focus on engineering tasks within the basic training. Context problems and creative tasks are included into basic projects that, together with possibility of training individualization, promote the students to actively search for additional information, simulation and full-scale modeling, learning the world, its spatial and quantitative relations. Each task is aimed at development of practical skills in numerical calculations using developed mathematical models with assessment of error output that envisages calculations using scientific calculators. To apply the results of problem solution into further practice, a student is to choose a unit system which, in each case, is related to a definite research object. The course contains only examples or problems in which model parameters correspond to its physical meaning or engineering content.

The means of modern information-communicative technologies are widely used in 'student-learning material' interaction. The special software is designed to verify the accuracy of graph construction of a free solid body. As a result of intensive interaction with the virtual environment and interactivity, a student acquires the skills in graph construction (external forces and constrained forces) when performing monitoring tasks. Solving the learning problems a student has a possibility to obtain a correct answer without limitation due to the developed automated system and work with comments of possible error register. The designed software is used to present kinematic magnitudes graphically.

To develop student research skills and engineering thinking, the on-line course comprises a basic project of simulation model development of a real engineering body. Problem statement of the project can vary in compliance with educational programme profile. The basic project is performed step-by-step during several weeks. The final stage of basic project implies students' independent assessment of their creative section.

The course implementation has shown that a teacher can supervise the class of 500 students owing to students' involvement into tutorial activity.

To scale-up the monitoring and individualize their performance, a data selection system was developed for control-assessment materials. Nearly unlimited variability of control-assessment material is achieved through the software designed to change parameters by means of built-in randomizer. In this case, the changes in variable parameters are defined by analysis of real processes and phenomena, the mathematical models of which have been developed. It also relates to geometrical parameters, kinematic, dynamic, and other magnitudes. In some cases the model parameters were obtained from dynamic problem solutions not included in the given course, but providing the adequate image of engineering problem statement. The examples are the selection of: steering angle of an automobile, automobile motion law when doing a looping-the-loop, automobile motion parameters along a highway, parameters of plane aerobatics operations etc. Selecting the data for the problems set, the course authors sought for constructional, geometrical, technological, physical parameters in references, engineering literature, patents, standards, in research journals and Internet.

The course provides the connections with pre-requisites and co-requisites as well as a unity of basic education. The earlier acquired knowledge on many natural and engineering disciplines is organically built in the course. Besides, the possibility of using the information in post-requisites is described. The examples are skills used in generating curves, differentiation and integration of composite functions, engineering graph skills in pictorial projection construction, physical knowledge of common concepts of speed and acceleration, competence of using information technologies, such as 3D-modeling, motion animation, transfer from mathematical model to process programming, use of on-line calculators in engineering calculation and on-line tools to plot graphs of the function parametrically set, etc.

In January, 2016, at the Gaidar Forum German Gref in his report told about on-line learning and education: "I generally do not believe in on-line education of the previous century. On-line learning has to be radically changed. Now it is still the same as traditional one, i.e. we have transferred traditional education into on-line. In our opinion, both the former and the latter…, are losers. On-line course will be used, but the learning content will be completely different and teaching methods will be completely different. We need to change the model of education")[1].

The launch of "Engineering mechanics" course on the National Platform of Open Education has shown its efficiency in training second-year students of Ural Federal University. At mid-year exams the students' performance indicators far exceeded similar indicators of the previous year. The examination of electronic learning (table 1) took place on-line with personal identification without direct teacher's participation in examination.

The main result is radical changes of content and form of traditional material delivery on mechanics. For educational programmes of "Engineering and technical sciences" profile "Engineering mechanics" course lays the foundation for achieving the learning outcomes of engineering modules [8], which involves interdisciplinary project [9] and demonstrates the unlimited potentials of on-line techniques.

Table 1. The number of students taught by different methods

	Students of on-line course, 2015	UrFU traditional learning, 2014-15	UrFU electronic learning, 2015-16
The total number of students	517	323	186
Students with high learning outcomes	292	213	179

[1] The Gaidar Forum. 2016:report by German Gref URL: https://www.youtube.com/watch?v=Tkj3sE492To

REFERENCES

1. Ob obrazovanii v Rossiiskoi Federatsii [Elektronnyi resurs]: fe-der. zakon ot 29 dek. 2012 g. № 273-FZ. [On education in the Russian federation]. Moscow, 2012. 404 p. URL: http://minobrnauki.rf/documenty/2974/file/1543/12.12.29-FZ_Ob_obrazovanii_v_Rossiyskoy_Federatsii.pdf, (Accessed: 19.12.2016).
2. Gosudarstvennaya programma Rossiiskoi Federatsii «Razvitie obrazovaniya» na 2013–2020 gody [Elektronnyi resurs]: utv. rasporyazheniem Pravitel'stva Ros. Federatsii ot 15 maya 2013 [State Program of the Russian Federation 'Development of Education' approved by the Government of the Russian Federation]. №792-p. [Moscow, 2013].700 p. URL: http://minobrnauki.rf/dokumenty/3409/file/2228/13.05.15-Gosprogramma-Razvitiye_obrazovaniya_2013-2020.pdf, (Accessed: 19.12.2016).
3. Livanov D.V., Volkov A.Ye. Stavka na novoe soderzhanie [Elektronnyi resurs]. Vedomosti [Bulletin]. 2012. № 3179. URL: http://www.vedomosti.ru/opinion/articles/2012/09/03/stavka_na_novoe_soderzhanie, (Accessed: 19.12.2016).
4. Konanchuk D., Volkov A. Epokha «Grinfilda» v obrazovanii [Epoch of 'Greenfield' in education] [Elektronnyi resurs]: SEDeC; Center of education development of Moscow Management School SKOLKOVO (SEDeC). Skolkovo, 2013. 52 p. URL: http://www.skolkovo.ru/public/media/documents/research/education_10_10_13.pdf, (Accessed: 19.12.2016).
5. Mityushov E.A., Berestova S.A. Teoreticheskaya mekhanika: ucheb. [Theoretical mechanics]. Moscow: Akademia, 2006. 320 p.
6. Mityushov E.A., Berestova S.A. Teoreticheskaya mekhanika: ucheb [Theoretical mechanics]. 2-e izd. Moscow: Akademia, 2011. 320 p.
7. Belayeva Z.V., Berestova S.A., Denisov Yu.V. et al. Teoreticheskaya mekhanika v primerakh i zadachakh [Theoretical mechanics in examples and problems]. Mityushov E.A. (eds.). Moscow: Akademia, 2012. 176 p.
8. Berestova S.A. Proektirovanie obshcheinzhenernogo modulya programm proizvodstvenno-tekhnologicheskogo bakalavriata [Project of general-engineering module of production-technology Bachelor programs]. Inzhenernoe obrazovanie [Engineering education]. 2014. № 14. P. 100–105.
9. Rebrin O.I., Sholina I.I., Berestova S.A. Interdisciplinary project for Bachelor Engineering Program [Electronic resource]. Sharing successful engineering education experiences: 10th Int. CDIO Conf., Barcelona, Spain, June 16–19, 2014: Proc. Barselona, 2014. [9 p.]. URL: http://www.cdio.org/files/document/cdio2014/14/14_Paper.pdf, (Accessed: 12.12.2016).

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Monitoring Math Competency of IT Students

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The paper studies a method to develop testing and assessment materials, which is based on splitting "classical" parts of mathematics into smaller disciplines. It reveals the opportunities of the method in terms of competency-based approach.

Key words: competency approach, testing and assessment materials.

Introduction

Competency approach implemented into educational standards challenges many education programme designers. One of the challenges is competency mapping and developing relevant testing and assessment materials, which can be used at each stage. This paper describes how to overcome this challenge and simultaneously solve many other tasks and difficulties, which education programme designers normally face.

Mathematical disciplines for IT students

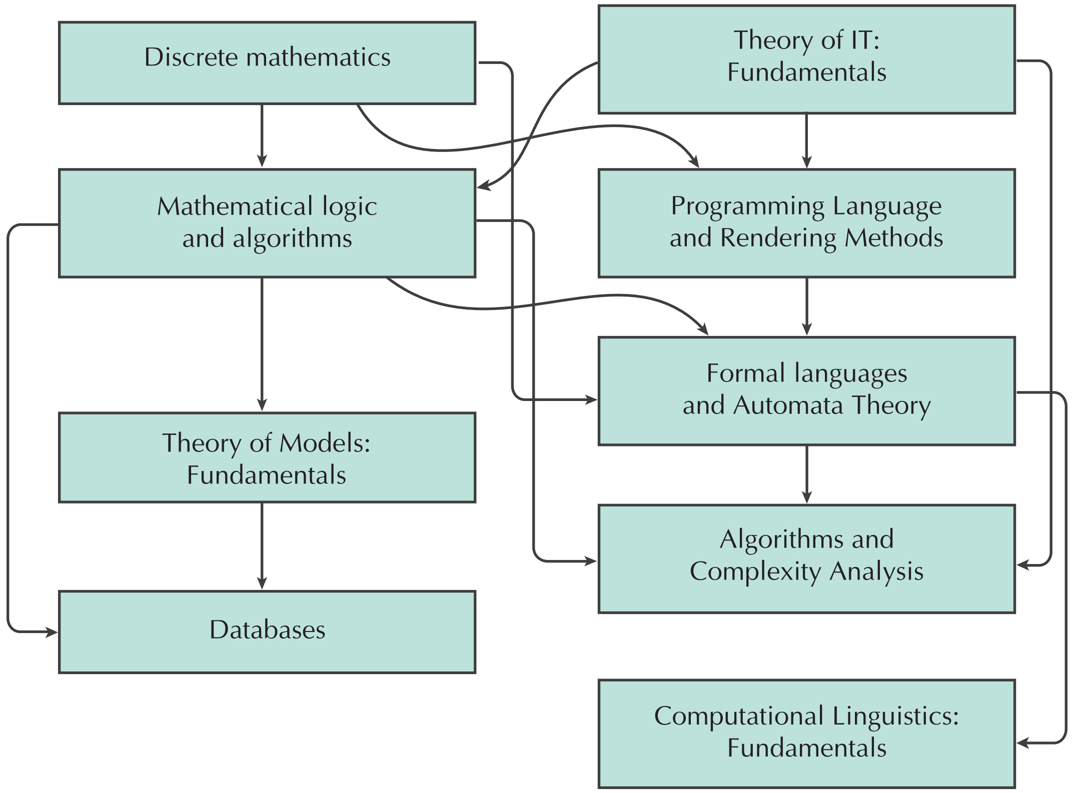
Training high-qualified IT professionals is impossible without profound mathematics education. Unfortunately, in the Russian language we still lack an appropriate term to call this section of mathematics. English "Computer Sciences" can be interpreted in different ways – either literally or transforming into "theory of IT", "IT fundamentals"; "math fundamentals for IT", etc. Nevertheless, one can identify the key subfields which are consistently incorporated into this mathematical course: different areas of discrete maths (theory of graphs, theory of Boolean functions, theory of coding, etc.), formal languages and automata theory, mathematical logic, algorithms, some topics of general algebra. Other disciplines incorporated into this course are optional and depend on a particular education programme, for instance, calculus of probabilities or numerical mathematics (see [1, 2]). Other mathematical subfields, if included, are regarded as supportive (for instance, calculus), since relevant knowledge and skills are also developed within other disciplines but rarely used in professional activities.

The incorporated disciplines are interrelated: either one discipline follows the other discipline or they are mutually influence each other. In this latter case, the contents of two disciplines are interdependent, which challenges programme and curriculum design. A typical example is mathematical logic and algorithm. On the one hand, fundamentals of both disciplines can be taught independently, but if to go deeper, one can see that these disciplines are strongly connected and can be taught as one subject. However, this method does not always work and a dozen of disciplines can never be taught as the only one. The probable decision is to teach several subjects simultaneously, but this is quite challengeable in practice. Another option is to split the discipline into smaller sections, which can be taught in different time. First, fundamentals, which are essential for other disciplines, are taught, and later it is possible to go deeper. However, the problem is that by the time, when the subject is learned in detail, students will have already forgotten some of the fundamentals, and the teacher and students have to spend extra time revising.

Another challenge is to motivate student to learn theoretical subjects. It is no secret that many students want to quickly acquire professional skills without learning fundamentals. It is particularly true for the first year students due to the decreased level of training at schools and no occupational guidance for school children. And here one faces the same challenge again: on the one hand, it is logical to start with fundamentals and then pass to practical application, but on the other hand, IT students have low motivation for studying theory and sometimes possess insufficient background knowledge of math. To solve this problem, one can follow the ways mentioned above: unite several subjects within one discipline, study several subject simultaneously, or study the same subject several times (at different levels).

We suggest using the model shown in fig. 1 (see also [1]) but do not go as far as stating that it is ideal. As one can see, Discrete Mathematics and IT Fundamentals are introductory courses and provide only basic knowledge, which students can deepen over the following years of study.

Fig. 1. Dependence between IT fundamental disciplines



Development of Assessment Materials

Testing and assessment materials for the model given above are similar for different subjects since the concepts are often the same and students have an opportunity to revise the material studied.

Moreover, this contributes to resolving one of the tasks which an education programme designer faces within competency approach (see [3]). Competency mapping is an essential stage in designing education programme within the competency approach. This map describes each competency elements and learning stages. Testing and assessment materials are designed to monitor competency development at every stage. The suggested model implies that within each section there are tasks at different levels of complexity (from elementary to more complicated),

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which can be represented as a graph of competency (or its element) development.

Let us consider several cases. One of Bachelor's competencies within professional profile 02.03.02 is PK–2: an ability to comprehend, develop, and apply up-to-date mathematical tools, concepts, and methodologies, international and professional IT standards. This competency is complicated enough and implies studying a lot of materials. Let us describe how to monitor the development of the ability to comprehend, develop, and apply up-to-date mathematical tools, one of the elements within the given competency.

The section devoted to formal grammar and automata is repeated within the model at least five times:

- learning fundamental concepts in "Discrete Mathematics";
- application of grammars and automata for description of a programming language and rendering in "Programming Language and Rendering Methods";
- advanced level course "Formal languages and Automata Theory";
- application of automata for text processing in "Algorithms and Complexity Analysis";
- application of context-sensitive grammar for automatic analysis and language processing in "Computational Linguistics: Fundamentals".

This example shows that courses providing theoretical knowledge on formal grammars and automata interchange with those implying practical application of the knowledge obtained.

The relevant testing and assessment materials allows monitoring the level of formal language competency development:

1. Basic level, Discrete mathematics – simple tasks on designing finite-state machines, regular expressions, and the simplest properties of regular languages:

- To design a finite-state machine recognizing the definite language.
- To design a regular expression describing the definite language.
- To prove that the definite language is not regular.

2. Intermediate level, Programming Language and Rendering Methods - tasks on designing lexical and syntactical analyzers, the simplest context-free grammars and nested stack automata:

- To design grammar for the definite programming language.
- To design a lexical analyzer.
- To design a syntactical analyzes.

3. Intermediate level, Formal languages and Automata Theory – tasks implying specific knowledge about languages and their properties:

- To design grammar, equivalent to the given one, in strong Greibach normal form.
- To prove that the given language is not context-free.

4. Advanced level, Algorithms and Complexity Analysis – tasks on designing efficient text processing algorithms:

- To design a string-matching automaton based on Morris-Pratt algorithm.
- To implement linear-time algorithm for a two-way nested stack automaton.

5. Advanced level, Computational Linguistics: Fundamentals – tasks on designing grammars more complicated than context-free ones:

- To design dependency categorial grammar for the definite language.
- For the definite language, to design the grammar which does not parse expressions.

Let us consider another example involving formal algorithm and calculation. Once again, it is the section that students face several times:

- Theory of IT: Fundamentals – the simplest models of programming languages (structured, functional, etc.) and their equivalence, some experience in computational complexity.
- Discrete Mathematics – Turing machines and model simplification, as well as undecidable problems.
- Mathematical logic and algorithms – review on mathematical modelling,

algorithms, and their properties, fundamentals of the theory of recursive and recursively enumerable sets, complexity classes.

- Algorithms and Complexity Analysis – different calculation models to design an efficient algorithm, complexity classes (studied earlier) for task analysis.

This sequence enables developing PK-2 competency in terms of another element – decidability and computational complexity:

1. Basic level, Theory of IT: Fundamentals – tasks on designing algorithms in different languages and their transformation:

- To design a structured programme for the given task.
- To transform a structured programme into a functional one.

2. Basic level, Discrete Mathematics – tasks on algorithm transformation and the simplest tasks involving undecidable problems:

- To demonstrate that in any Turing machine it is possible to eliminate operations preventing the machine from moving its head.
- To prove that the problem of reachable state for Turing machine is undecidable.

3. Intermediate level, Mathematical logic and algorithms – tasks on designing different types of algorithms, their transformation, undecidable problems, computational complexity:

- To design a definite partially recursive function.
- To design a counter machine for this function.
- To prove that the definite set is m-full.
- To design a cellular automaton recognizing the definite sign taking time linear in input size.

4. Advanced level, Algorithms and Complexity Analysis – tasks on computational complexity:

- To prove that the problem is NP-complete.

One more example of information repeated is knowledge about logic programming languages:

- Discrete Mathematics – first insight into languages of propositional and predicate logic at the semantic level.
- Mathematical logic and algorithms – more difficult programming languages, formal inference, interconnection between logic and calculating.
- Theory of Models: Fundamentals – complex concepts linking syntax and semantics in programming languages.
- Databases – application of Programming Language Theory in query parsing.

Let us describe the stages in development of PK-2 competency in terms of programming languages:

1. Basic level, Discrete Mathematics – tasks on knowledge representation in programming languages, simplest transformations:

- To determine the formula of predicate logic describing the definite properties of the entity.
- For the definite propositional logic, to design the truth table, conjunctive and disjunctive normal forms, Zhegalkin polynominal.

2. Intermediate level, Mathematical logic and algorithms – tasks on inference and modelling:

- To obtain the definite computation sequence.
- To define the distributive law in Peano axioms.
- To enrich algebraic system so that the definite formula will be true.

3. Advanced level, Theory of Models: Fundamentals – task on connection between syntax and semantics:

- To prove that the definite property of the entity fails to be described by universal formulae.
- To identify 1-types in the definite system.

4. Advanced level, Databases – tasks on composing queries by means of relational algebra and inexpressibleness:

- To build a query in relational algebra with fixed-point operator, which returns all elements with the definite properties.
- To prove that it is impossible to describe the definite property in relational algebra without a fixed-point operator.

Conclusion

We have considered opportunities which arise from splitting big educational sections into smaller parts studied at different time. This strategy allows education programme designers to overcome both typical challenges and those faced within competency approach.

REFERENCES

1. Zakharova I.V., Dudakov S.M., Yazenin A.V. O razrabotke primernogo uchebnogo plana po UGNS "Komp'yuternye i informatsionnye nauki" v sootvetstvii s professional'nymi standartami [On the development of curriculum on UGNS "Computer and Information Science" in accordance with professional standards]. Vestnik Tverskogo gosudarstvennogo universiteta. Seriya: Pedagogika i psikhologiya [Bulletin of Tver State University. Pedagogy and Psychology], 2016, no. 2, pp. 84–100. (In Russ., abstr. in Engl.).
2. Zakharova I.V., Dudakov S.M., Yazenin A.V. O razrabotke magisterskoi programmy po UGNS "Komp'yuternye i informatsionnye nauki" v sootvetstvii s professional'nymi standartami [On the development of Master's programme on UGNS "Computer and Information Science" in accordance with professional standards]. Vestnik Tverskogo gosudarstvennogo universiteta. Seriya: Pedagogika i psikhologiya [Bulletin of Tver State University. Pedagogy and Psychology], 2016, no. 3, pp. 114–126. (In Russ., abstr. in Engl.).
3. Zakharova I.V., Dudakov S.M., Yazenin A.V., Soldatenko I.S. O metodicheskikh aspektakh razrabotki primernykh obrazovatel'nykh programme vysshego [Developing exemplary education programmes for higher professional education: methodological aspects]. Obrazovatel'nye tekhnologii i obshchestvo [The Journal of Educational Technology & Society], 2015, vol. 18, no. 3, pp. 330–354. (In Russ.).

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UDC 378.14

Concurrent Engineering Approach to Teaching Fundamentals of Geometry and Graphics in Higher Engineering School

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E.V. Usanova

The paper proves the efficiency of teaching fundamentals of geometry and graphics in the context of concurrent engineering and provides the results of problem- and project based team work performed by students within the scope of blended learning programme. Educational resources of the course comprise materials for declarative learning (educational tools based on GDP – PPT animation, logical schemes with frames, videos) and procedural learning (CAD-systems, graphic tests, different level tasks).

Key words: blended learning, learning fundamentals of geometry and graphics, graphic means of presenting information, problem-based modular learning, project-based method, team work.

1. Introduction

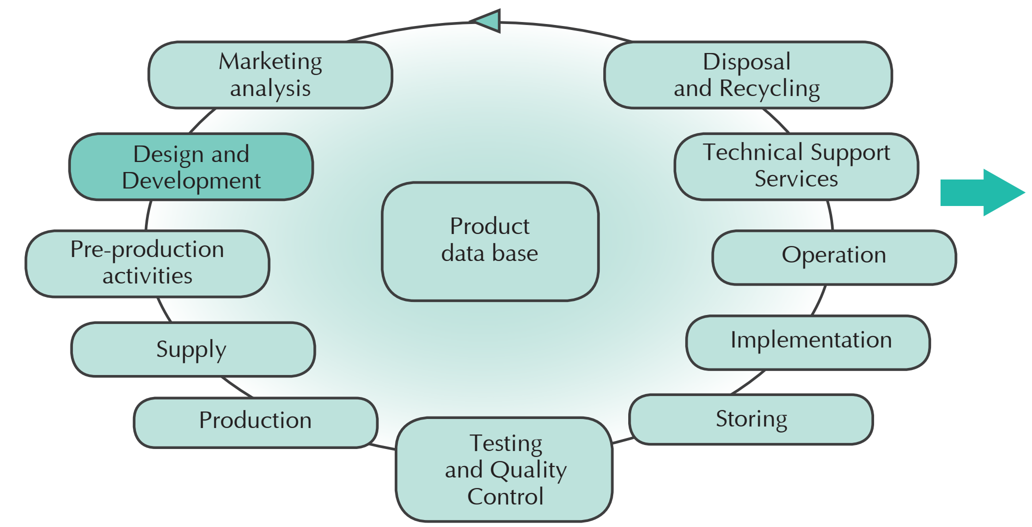
In the sphere of high-tech mechanical engineering, transition to concurrent engineering (CE) based on PLM software (Product Lifecycle Management) alters the nature of engineering activities, especially in terms of design and development. The foundation of CE rests on the principles of concurrent design, manufacturing, and PLM, which are implemented through integrated cooperation and simultaneous resolving of different tasks by the team of designers and experts. In CE/PLM, the integrated CAD/CAE/CAM-systems create particular design media, and the model designed in CAD-systems is an integrating digital product, which reflects interaction with all the elements and ensures graphic communications in enterprise digital media (EDM) over the product lifecycle. The activities of the design engineer in EDM are multifunctional and imply not only different types of activities, but also using principally different goal pursuits and strategies in resolving design tasks. Digital media used in CE/PLM for design engineering (DE) alters its approaches and techniques, which should be considered in engineer training. If for sequential flow of PLM-cycle (fig. 1, a) traditional discipline-based education was more or less acceptable, engineers working in CE/PLM should possess knowledge, skills, and abilities (KSA) essential for multi-aspect, and what is more important, integrated polytechnic thinking (fig. 1, b).

As a result, technical university graduates educated within the frame of discipline-based curriculum fail to be properly pre-pared for professional activities in CE/PLM. An urgent issue today is how to train new generation of design engineers able to create a competitive product in CAD-systems. To develop the required design engineering competencies, it is necessary to reform the system of teaching geometry and graphics (TGG), which are fundamentals of DE.

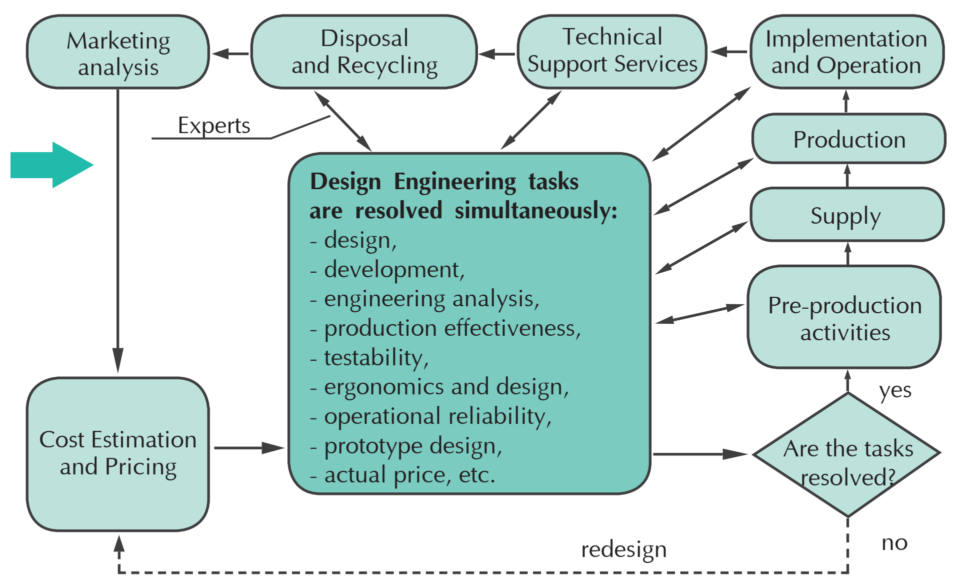
2. Systemic integration to ensure consistency in teaching geometry and graphics

The geometry and graphics curriculum is to be integrated on the basis of graphic software, and this is an essential criterion to set the goals, select and structure the content of the curriculum in accordance with social and professional requirements to engineers within CE/PLM. The curriculum components aimed to improve cognitive and practical skills important in professional context should

Fig. 1. Alteration of nature of engineering activities



a) PLM – sequential



b) CE/PLM – simultaneously

be integrated to increase students' intelligence and develop polytechnic mentality, so that they can be efficiently applied in DE and related fields.

TGG focused on CE/PLM can be split into two principle components – general professional and design ones, the former being basic for all programmes. The general professional component aims to develop geometry and graphics competencies essential for all engineers, while the goal of the design component is to improve the skills specific for a particular programme. Persistent IT development inevitably leads to alterations in TGG: content, forms, methods, techniques, means, and staff. Let us take a closer look at discussing a case study of TGG general professional component.

2.1. Teaching techniques. When teaching fundamentals of geometry and graphics in the context of CE/PLM, IT implementation is far-reaching and implies graphical data presentation (GDP) and using CAD-systems in e-learning. Today, they are commonly used both in Russia [1, 2, 3, 4] and abroad [5]. TGG based on IT transforms the structure of traditional education, intensifies learning process and increases the level of knowledge acquisition. It is noteworthy that an increase in students' intelligence is not restricted to greater volume and better quality of the knowledge acquired. Compared to traditional education, students develop alternative cognitive skills, diverse the way of thinking, alter the system of logical operations and mental activities.

The basic competencies in geometry and graphics are developed through active forms of team and individual work based on problem-based modular learning (PBML) and using GDP and CAD-systems. The problems designed initiate cognitive educational activities and affect the students' intelligence. Moreover, PBML in education ensures intradisciplinary and cross-disciplinary connections.

The curriculum content structured in modules and concentrated in GDP forms, which are developed to reach the teaching goals, allows one to perform the activities as follows:

- to timely design multi-path education process integrating modules or diversifying the content;
- to give the educational material in modules with some didactic elements in GDP abridging the materials and reducing the number of class hours to approximately 33–14% in a way that does not have any impact on intensity of perception or quality of knowledge acquisition [6, p.81]. Within each module, this allows focusing on practical tasks during class hours and over the time given for individual work;
- to ensure monitoring within each module, which, in its turn, secures reaching the educational goals;
- to adjust education process to students' needs and abilities, which stipulates self-education at one's own pace;
- to focus on consulting and coordinating educational activities, with stimulating self-study in different forms of e-learning:
  - under the teacher's supervision (class hours);
  - completely individually (virtually);
  - individually but with a teacher consulting (blended learning: class work and virtual learning based on LMS).

According to the European University Association (EUA), in 2013 the most preferable form of e-learning (91%) was blended learning (46%) [7, p. 26].

2.2. Geometry and Graphics Fundamentals: Content. The priority in selecting and structuring materials for TGG is to develop basic level competencies essential to perform professional activities in CE/PLM and to continue education in DE using professional software. The goals of basic level training are as follows:

- to develop abilities for analysis and synthesis of geometrical shape;
- to prepare students for self-education and work with on-line self-study programmes to learn different ways of shape generating and annotating design documents using CAD-systems;
- to prepare students for team and individual work aimed to resolve DE tasks.

The educational course is regarded as a tool for self-development and the content is presented in modules based on:

- visual aids in representing educational materials;
- integrated educational process, sequential stages, and practice-oriented content;
- basic notions and methods being key components of the content structure;
- consistent and coherent materials;
- focus on self-study.

Modules are based on systemic analysis of conceptual framework of geometry and graphics, which allows one to identify key concepts, select the materials essential for the module, avoid repetitions within the course and in the related disciplines.

Fig. 2 shows the structure of the modular learning programme used for TGG.

The integrating goals of modules (fig. 2) contain particular goals, which can be reached using educational tools. The module content comprises basic (permanent) and optional parts, the latter being connected with updating information and programme profile. The module structure includes:

- programme of actions given as education goals;
- educational materials and support structured in the form of education components;
- assessment and self-assessment tools for each module.

2.3. TGG in E-Learning: Forms, Methods, Tools. Methodological approach, which the key principles of TGG depend on, is based on the system of approaches (activity-based, competency-based, systemic, etc.), concepts and didactic principles, with due regard to psychological mechanisms of KSA acquisition. In e-learning interaction between teachers, students, and online courses implies equal cooperation. Students are free in and responsible for the choice of learning path: if necessary, students can even design individual learning paths.

Fig. 3 shows experience of KNRTU-KAI in TGG fundamentals focused on blended learning, designed on Black board learning platform, and comprising integrated educational modules.

Educational resources of the course comprise materials for declarative learning (educational tools based on GDP – PPT animation, logical schemes with frames, videos) and procedural learning (CAD-systems, graphic tests, different level tasks). In terms of the content, the course includes such modules as "Technical drawing and GDP fundamentals", "Industrial Design: Fundamentals" (fig. 3). CAD-systems allow one to resolve the tasks of shape generating taking into account design principles.

The module "Assembly Unit Modeling and Part Design" implies problem- and project-based learning in teams [8]. The module is designed for the first year students (second semester), and since the students lack professional knowledge at the current education stage, education is provided in the form of the role-play. The range and distribution of roles depend on the problem set, which can be either analogue (in terms of unit type, shape complexity, assemblage methods, etc.) or heuristic (correcting the shape of the assembly unit part, new shape generating, etc.). The focus is on self-study in 3D solid modeling and team work, which allows using knowledge of different levels to develop the skills of assembly unit modeling. TGG based on blended learning is particularly efficient, which can be proved by the case-study of the Institute for Automation and Electronic Instrumentation (IAEI), KNRTU-KAI (fig. 4).

Team work broadens the scope of tasks increasing students' intelligence and

Fig. 2. Structure of modular learning programme used for TGG
MG – main goal, IG – integrating

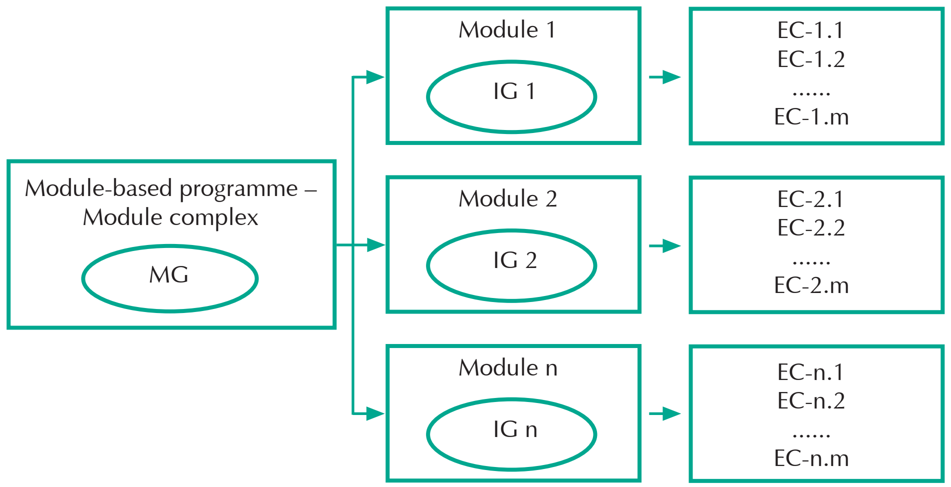
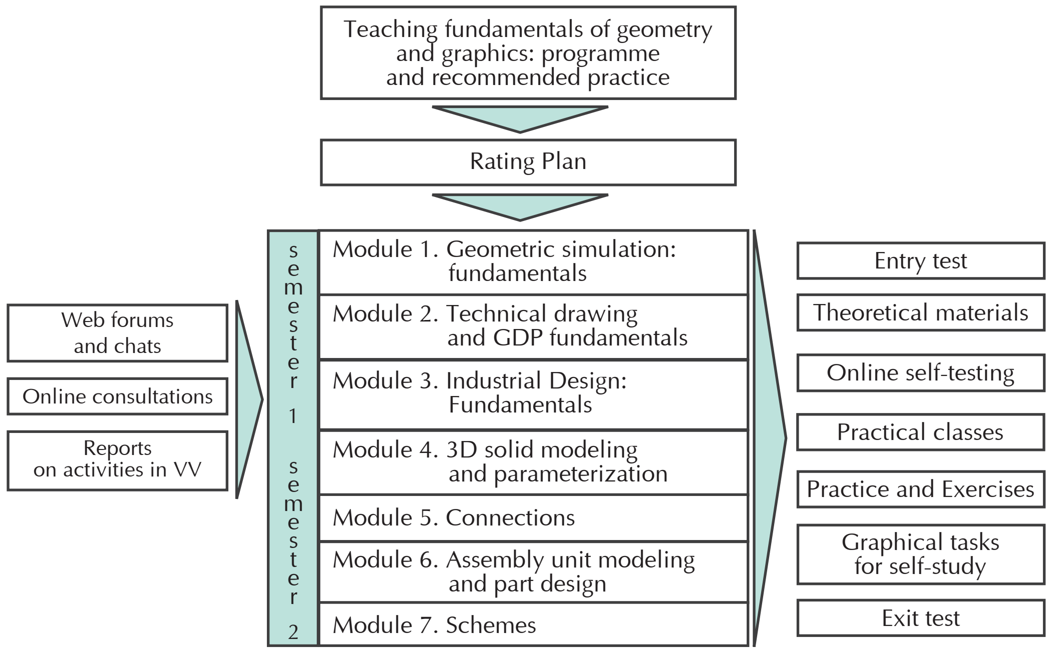


Fig. 3. TGG: education process



responsibility in taking decisions. Problem- and project-based learning makes it possible to train a team of design engineers and develop project mentality from the first stage of TGG. Since CAD-systems secures better quality in less time, their use for 3D-modeling and application of GDP in blended learning are indisputably beneficial.

2.4. Staff Assistance. Besides scientific and methodological rationale, implementation of graphic IT is inseparably connected with "staff training and retraining" [9, p. 50] in the spheres of didactics and IT development in education. IT penetration in TGG (the use of GDP and CAD-systems) is also associated with some psychological particularities, which can be efficiently used in educational process. The teachers should exploit the didactic potential of IT tools and develop students' intuitive reasoning, image thinking, and other rewarding professional qualities important for engineers working in CE/PLM.

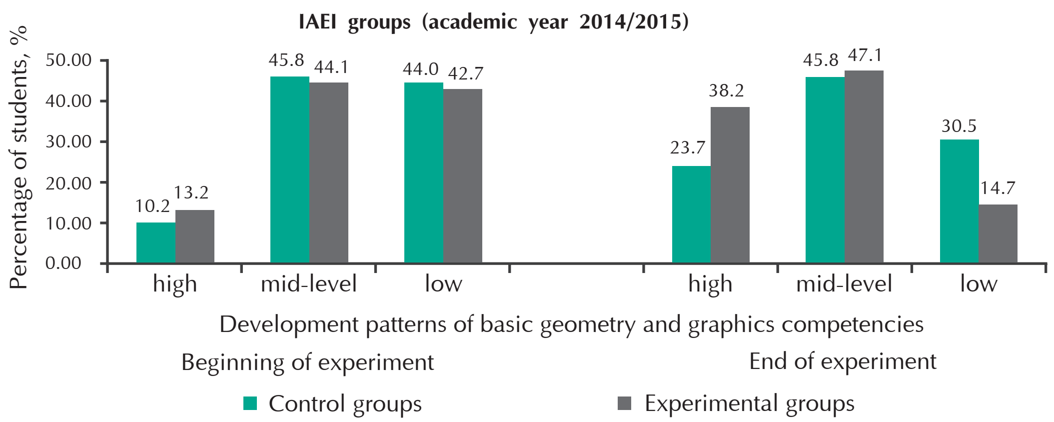
Conclusion

The synergetic effect of using GDP and CAD-systems in problem- and project-based modular learning on the efficiency of TGG is caused by the factors as follows:

- high potential of cooperative creativity due to graphical techniques applied in information visualization and active learning: project-based learning, team work characterized by high level of individual responsibility, online and off-line communication between the teacher and the student within the scope of educational process;
- tight presentation of materials, tests, and quick assessment in each module. The students are engaged in cognitive activities, which are connected with reflection on and review of the studied information, as well as practical application of the acquired knowledge;
- educational process within each module can be controlled by the teacher and adapted to the individual needs of the student, who can design an individual learning path.

All together, these factors ensure high quality of TGG fundamentals.

Fig. 4. Basic geometry and graphics competencies: development patterns



REFERENCES

1. Abrosimov S.N., Tikhonov-Bugrov D.E. Proektno-konstruktorskoe obuchenie inzhenernoi grafike: vchera, segodnya, zavtra [Design and engineering training in engineering graphics: past, present, future]. Geometriya i grafika [Geometry and graphics], 2015, vol. 3, no. 2, pp. 47–57. (In Russ., abstr. in Engl.).
2. Gornov A.O., Usanova E.V., Shatsillo L.A. Bazovaya geometro-graficheskaya podgotovka na osnove 3D-elektronnykh modelei [Basic geometry and graphics training on the basis of 3D electronic models]. Geometriya i grafika [Geometry and graphics], 2014, vol. 2, no. 3, pp. 46–52. (In Russ., abstr. in Engl.).
3. Guznenkov V.N. Geometro-graficheskoe obrazovanie v tekhnicheskom universitete [Geometry and graphics in higher technical school]. Alma mater (Vestnik vysshei shkoly) [Alma Mater (High School Herald)], 2014, no. 10, pp. 71–75. (In Russ., abstr. in Engl.).
4. Usanova E.V. Kompleksnoe primenenie media-tekhnologii i CAD-sistem v geometro-graficheskoi podgotovke studentov [Composite application of media technologies and CAD systems in geometrical and graphic training of students]. Geometriya i grafika [Geometry and graphics], 2013, vol. 1, no. 1, pp. 63–67. (In Russ., abstr. in Engl.).
5. Tominaga H. et al. A research of multimedia teaching materials for 3-dimension cad education [Electronic resource]. Proc. 16th Int. Conf. on Geometry and Graphics, Innsbruck, 2014, pp. 1048–1054. URL: https://www.uibk.ac.at/iup/buch_pdfs/icgg2014.pdf (Accessed 12.12.2016).
6. Usanova E.V. Povyshenie effektivnosti bazovoi geometro-graficheskoi podgotovki v tekhnicheskom vuze [Improving the efficiency of the base geometry-graphic preparation in technical universities]. Kazanskii pedagogicheskii zhurnal [Kazan pedagogical journal], 2015, no. 4, pp. 78–82. (In Russ., abstr. in Engl.).
7. Gaebel M. et al. E-learning in European higher education institutions [Electronic resource]. Brussels, 2014. URL: http://www.openeducationeuropa.eu/sites/default/files/news/e-learning%20survey.pdf (Accessed 12.12.2016).
8. Usanova E.V. Formirovanie bazovogo urovnya geometro-graficheskoi kompetentnosti v elektronnom obuchenii [Formation of the basic level of geometry and graphics competence of students in e-learning]. Geometriya i grafika [Geometry and graphics], 2016, vol. 4, no. 1, pp. 64–72. (In Russ., abstr. in Engl.).
9. Solovov A.V. Elektronnoe obuchenie: problematika, didaktika, tekhnologiya [E-learning: topics, didactics, techniques]. Samara: Novaya tekhnika, 2006. 464 p.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Towards General Developmental Curriculum "Fundamentals of Mathematical Engineering Modeling"

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An innovative general developmental curriculum is suggested for extra school training. It has been developed within the framework of the Russian Education Ministry assignment aimed at establishing nation-wide practice-oriented science and technology clubs for engineering creativity. Distinctive features of the curriculum are project-based learning and an emphasis on mathematical modeling in design and engineering. The purpose of the programme is to promote the engineering profession and education in the country, develop the bases for engineering thinking of a new type in upper form pupils. This type of thinking is required to solve the problems of the new generation associated with intelligent control, artificial intelligence and other issues commonly known as "Future Engineering".

Key words: engineering modeling, construction, future engineering, mathematical modeling, general enrichment educational programme.

Introduction

At the moment the specialists of engineering profiles with new research thinking are increasingly in demand in Russia. Simultaneously, due to penetration of engineering and technology in all spheres of human life, the problems solved by an engineer are continuously becoming more complicated. A modern specialist is required not only to know some information, but, first of all, be able to use it in solving non-standard problems, which have not been explicitly taught within the university study as they are cross-disciplinary.

For example, rapid research development of the 20th century in the sphere of artificial intellect resulted in a new type of problems requiring an engineer not only to have basic engineering education, but also profound mathematical training necessary to understand fundamentally new concepts, such as: intelligent control (for instance, in design problems of so-called "smart house"), possible issues of artificial intellect, software engineering, robotic technology, fuzzy intellectual systems, soft computing, bioinformatics, etc.

The training of such new type engineers should be started as early as at the school age. The first thing that should be taught for future engineers is bases of engineering modeling, since modeling and design are basic skills of any engineer that contribute to practical learning about the world, develop engineering thinking, stimulate for creative self-development, and, are, subsequently, a factor for professional advancement. In this condition, mathematical and closely connected with it computer modeling used for solving engineering problems have become one of the key components in engineering modeling.

Despite the growing demands of labour market for engineers of new generation, applicants still prefer to enter juridical, economic, and managerial departments. Therefore, one of the principle problems faced by the government today is to promote physics-mathematical, engineering and natural science education. This problem is also necessary to be solved as early as at the school level at the time when schoolchildren develop their preferences in future job choice.

All these facts condition the urgency of developing additional general educational and developmental programmes [1-4] focused on pupils' involvement in engineering art, development of constructive thinking, and, as a consequence, motivation for future engineering job.

The current article describes the result of such work in the form of developmental curriculum "Bases of mathematical engineering modeling" for additional general education. The goal of the curriculum is to promote engineering jobs and engineering education in the country, decrease the graduates' withdrawal studying at engineering departments to other specialities, as well as senior pupils' acquisition of engineering thinking bases of new type, necessary for a contemporary engineer to solve the problems of new generation related to intellectual control, artificial intellect, and other issues of "future engineering".

The novelty of the curriculum consists in the fact that it relies on the issues of mathematical modeling: from the simplest questions of physical process modeling based on ordinary differential systems to the issues of complex process and phenomena modelling of stochastic and fuzzy nature using corresponding mathematical tools of possibility and probability theories, elements of intellectual control based on evolutionary algorithms, neural network, and fuzzy-logic controllers.

The curriculum content is adapted for senior pupils who have already got familiar with the bases of integral and differential calculation and have basic knowledge of algorithm development and programme writing in one of the structured programming languages.

The distinguishing feature is training based on one of the most common programming languages – Python which is free, simple to install and study, and keeping up with expressive power of modern languages such as C/C++, Java, C# and etc. Simple syntax and all basic data structures built in language allow more attention to practical study of the course theoretical concepts without much waste of time for tools.

One more feature is application of project-based technique that allows developing skills of team project work: pupils are divided into groups of 2-3, each group performs one of the suggested projects. At the end of the course the project results are presented for defense. All project tasks are divided according to the complexity level that enables to take into account children's age and individual characteristics.

Course content

The whole course is logically divided into four parts, each of which deals with definite modeling level whose complexity increases from part to part. The first part is the very first step in learning modeling, i.e. simulation of physical processes. These are the simplest and visual examples allowing pupils to understand what modeling is and why it is needed. The second part is concerned with traditional modeling of physical processes based on the simplest differential equations aimed at solution of practical problems. Mathematical tools used in this part are adapted for the school level: all models are built on the bases of ordinary differential equations of the first order which solutions are made by the Euler-Cauchy method. The third part considers modeling of more complicated processes which cannot be analytically described, and work on the "secret box" principle whose behavior can be evaluated only by some external signs of their functioning, where one needs to use simulation modeling. Finally, the fourth part is concerned with intellectual modeling of complex processes and phenomena, where the elements of artificial intellect (evolutionary algorithms, fuzzy systems, and soft computing) are used.

The course is structured into two parts. The former deals with engineering mathematical modeling, design, project-based approach itself. This part takes 36


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hours, within which pupils learn project-based technique performing simple projects in graph simulation of physical processes. In addition, pupils also learn to present the project results in the form of PP presentation at the end of the first half course.

The second part deals with the problems of engineering modeling (design), i.e. development of nontrivial systems based on modern intellectual methods enabling to solve small engineering problem. When performing the tasks of the second part the project-based technique is used. Pupils choose one of the suggested projects and work at it up to the course end. The results are presented for defense.

In the middle of the course there is an intermediate project defense, whereas the knowledge is monitored at the end of academic year in the form of final project defense. Both the former and the latter take place with result presentation in PowerPoint format.

Course content

We are presenting the components of curriculum and its content. The course takes 72 hours, 32 of which are intended for theory and 40 hours – for practice. The course is structured in such way that its practical part suggests both class and distant work (independent project work, learning material, teacher's consultations via e-mail or by means of other communication tools).

Unit 1. Introduction to engineering modeling (design) (2 h.)

Theory (2 h.): What is engineering? What is engineer? Types of engineering activity: 3D modeling, design, robotics, mathematical modeling, programming. Past, present and future of engineering, intellectual control, artificial intellect. Project-based technique. The project structure, its stages, project presentation. Elements of programming engineering in project-based technique. Entrance test to define pupil's level.

Unit 2. Introduction to Python programming language (10 h.)

Theory (6 h.): Computers and programming languages. Interpretation and compilation. Python Programming language. Design environment. Language syntax. Object-oriented and dependent-chance programming.

Practice (4 h.): Installation. Learning language and design environment. Python language syntax and key structures. Doing exercises. SimpleGUI user's interface design. Simplest geometrical drawing on a canvas.

Unit 3. Bases of mathematical modeling (2 h.)

Theory (2 h.): Mathematical model, principle stages. Direct and inverse problems of mathematical modeling. Genericity, analogue principle. Model hierarchy. Examples of modeling.

Unit 4. Visualization of simplest physical simulations (4 h.)

Theory (2 h.): SimpleGUI animation. Modeling of perfectly elastic collision of a ball with a surface and two balls collision in air-free environment.

Practice (2 h.): Programme design to visualize model.

Unit 5. Description and selection of study projects in graphic simulation of physical processes, project work (12 h.)

Theory (2 h.): Task description to perform study projects using the following models: (1) Brownian motion model: an option of dynamic control of particle diameter, initial temperature, potentials of cooling environment (momentum loss at collision with vessel), drawing of particle motion trajectory on a separate screen; (2) diffusion of two gases: dynamic control of gas density, gap width between vessels, gas temperature (particle velocity), diffusion coefficient calculation of both vessels on a separate screen; (3) pendulum model: non-convergent and convergent oscillations; (4) simulation of "Life" game with graphic visualization, development and study of different strategies. The project goal is to learn project-based technique, study and develop corresponding model, programme simulation and visualization, preparation and presentation of results.

Practice (10 h.): the pupils' group is divided into subgroups, each of which chooses a project. Before the middle of the course the subgroups develop their topics at the practical classes, at the end of the course there is a presentation of study projects. At the theory classes more complex modeling based on differential equations is studied. The subgroups finishing work before the deadline have a possibility to complicate their projects by adding dynamics described in differential equation.

Unit 6. Elements of computing mathematics (1 h.)

Theory (1 h.): The simplest ordinary differential equations (ODE). ODE systems. Numerical differentiation. The Euler- Cauchy method of ODE solution (ODE systems).

Unit 7. Free falling body (1 h.)

Theory (1 h.): Newton's second law. Free falling ball model in the air-free and viscous environment.

Unit 8. Motion of body thrown at an angle to the horizon (2h.)

Theory (2 h.): Motion model of a ball thrown at an angle to the horizon with and without environmental resistance.

Unit 9. Project presentation (2 h.)

Theory (2 h.): Presentation of study projects defending theoretical results in the PowerPoint format and practical results in the form of operating simulation. The review of project results.

Unit 10. Description and selection of final projects, project work (18 h.)

Theory (2 h.): Description of final project tasks using the following model: (1) development of computer visual system to recognize printed characters based on neuron networks; (2) optimization of оптимизация генетическим алгоритмом multi-criterion complicated function describing physical process; (3) simulation modeling of signal-controlled junction service system (calculation of optimal time to change a light at the junction depending on pedestrian traffic schedule and intensity); (4) the problem of increased complexity: building controllers of inverted pendulum; (5) the problem of increased complexity: building fuzzy controller based on neuron control network of transport stopping before obstacle. The project goal is to study and develop non-trivial system (Python programming) based on modern intellectual models and methods allowing solution of logically completed engineering problem.

Practice (16 h.): Pupils subgroups choose the projects and work at them up to the practical classes up to the course end. The theoretical classes review different methods of complex process modeling with doing simplest demonstrational exercises.

Unit 11. Simulation modeling using the examples of service systems (4 h.)

Theory (2 h.): the key concepts of service system theory. Applications, building of probability distribution using frequency list, building of random-event generator using frequency list. Examples of service systems. Simulation modeling. The principles of simulation modeling system operation, multithreading, system object model, current software packages and libraries.

Practice (2 h.): Writing a programme to simulate modeling service system by the example of the simplest problem (the problem example: "Bus stop" – the task is to calculate the canopy square (in man-space) of a bus stop so that all passengers could keep the rain out at specified intensity of passengers' entrance and bus schedule independent of rain duration).

Unit 12. Genetic algorithms (4 h.)

Theory (2 h.): Evolutionary algorithms. Operation, origin, spheres of application. Structure of genetic algorithm. Advantages and disadvantages. Review of other intellectual optimization algorithms.

Practice (2 h.): Writing programmes to find optimal solution of the simplest problem of genetic algorithm optimizing. Solution process visualization.

Unit 13. Neuron networks (4 h.)

Theory (2 h.): Artificial neuron networks, their origin and development. Spheres of application. Class of problems. Study of networks with a teacher. One-layer perceptron for solving classification problems. Network learning. Existing programme packages and libraries of artificial neuron network modeling. Review of basic architectures of artificial neuron networks.

Practice (2 h.): Writing programmes to classify vectors by means of the simplest one-layer perceptron.

Unit 14. Fuzzy logical systems (4 h.)

Theory (2 h.): Elements of fuzzy set theory: fuzzy set, membership function, triangulated fuzzy numbers, α-level set. The systems of fuzzy inference. Field of application.

Practice (2 h.): Writing a programme to simulate the simplest system of fuzzy inference.

Unit 15. Presentation of final projects, review of results (2 h.)

Theory (2 h.): Presentation of project results with theory in PowerPoint format and practical results in the form of operating programme. Review of the course results.

Conclusion

The article suggests innovative general educational programmes for additional schoolchildren education, the distinguishing features of which are project-based technique and focus on mathematical modeling in engineering design. The work was performed in the frame of State Project of the RF Ministry of Education and Science to arrange and develop practice-oriented research clubs of engineering art. In curriculum development the representatives of Tver State University, Lobachevsky State University of Nizhniy Novgorod, Kazan National Research Technical University named after A. N. Tupolev and Ogarev Mordovia State University took part, it was presented at the seminars held in Moscow and Saint-Petersburg.

REFERENCES

1. Ob obrazovanii v Rossiiskoi Federatsii [Elektronnyi resurs]: feder. zakon ot 29 dek. 2012. № 273-FZ [On education in the Russian Federation]. Garant.Ru. Moscow: Garant-service, 2017. URL: http://base.garant.ru/70291362. Accessed: 15.03.2017).
2. Ob utverzhdenii poryadka organizatsii i osushchestvleniya obrazovatel'noi deyatel'nosti po dopolnitel'nym obshcheobrazovatel'nym programmam [Elektronnyi resurs]: prikaz Min-va obrazovaniya i nauki Ros. Federatsii ot 29 avg. 2013. № 1008 [On approval of order of arrangement and implementation of educational activity based on the additional educational programmes]. Garant Moscow: Garant-service, 2017. http://www.garant.ru/products/ipo/prime/doc/70849796. Accessed: 15.03.2017.
3. Ob utverzhdenii Kontseptsii razvitiya dopolnitel'nogo obrazovaniya detei [Elektronnyi resurs]: rasporyazhenie Pravitel'stva Ros. Federatsii ot 4 sent. 2014. № 1726-r [On approval the concept of developing children's additional education]. Accessed at information-juridical system "ConsultantPlus".
4. Metodicheskie rekomendatsii po proektirovaniyu dopolnitel'nykh obshcherazvivayushchikh programm (vklyuchaya raznourovnevye programmy) [Elektronnyi resurs]: pril. k pis'mu Departamenta gos. politiki v sfere vospitaniya detei i molodezhi Min-va obrazovaniya i nauki RF ot 18 noyab. 2015. № 09-3242. [Methodical recommendations of designing additional general educational programmes]. Accessed at information-juridical system "ConsultantPlus".

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Perspectives of Smart System Math-Bridge for Learning Array Sorting Methods

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The article proposes the use of Math-Bridge smart system as a tool to train and control knowledge of engineering students in the methods of sorting arrays.

Key words: Math-Bridge, sorting, exercise, direct exchange, algorithm.

Application of training systems is one of the most advanced ways for educational information technology development. A training smart system Math-Bridge is a significant break-through made in this direction. It allows working with a wide scope of dynamic objects converted from usual graphic objects by means of a special editor [1]. A theoretical base for such systems was developed by Skinner B.F. and Crowder N.A. in the 1950-s of the 20th century. These systems are to take into account not only correct answers but also the ways that lead to the solutions [2]. Thus, the smart systems that provide a wide range of diverse objects and ready templates as tools are of special interest. The system is known to have been developed to train engineering students and students of natural science profile in the frame of MetaMath project [3, 4]. The course "Algebra and geometry" was developed in the frame of the project [5]. However, as practice shows, Math-Bridge toolkit can be successfully applied while training students from other majors [6].

This article studies the ways to use the system Math-Bridge to train and control the students of "Information and computer science" major on array sorting methods provided within the course "Algorithm and data structures". Specific features of creating dynamic training objects are used in this case [7]. Let us choose an Exercise as an object (fig. 1). This object can be directly used by making training algorithm via Educational material editor (fig. 1), or it is possible to choose one of the following (fig. 1, 2).

This approach is one of the easiest and fastest ways to create training and testing elements. The system includes six standard templates that allow designing exercises with one or two interactions with a trainee. The template types for exercise design are shown in fig. 2.

Besides, there is an opportunity to design dynamic objects by means of separate units, which allows implementing multi-level algorithms for further development of complex educational algorithms applied

Fig. 1. Dynamic objects and educational material editor

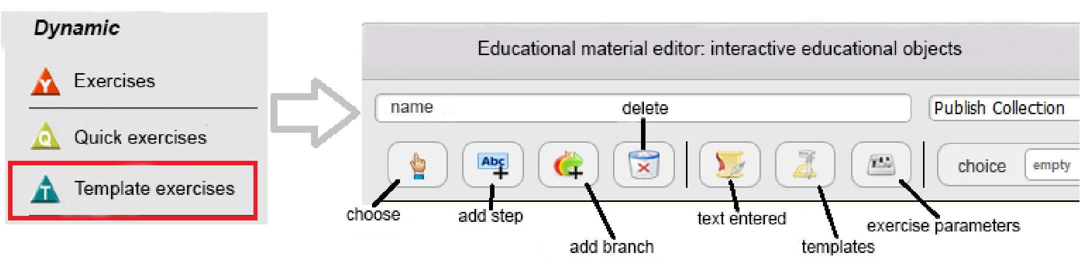
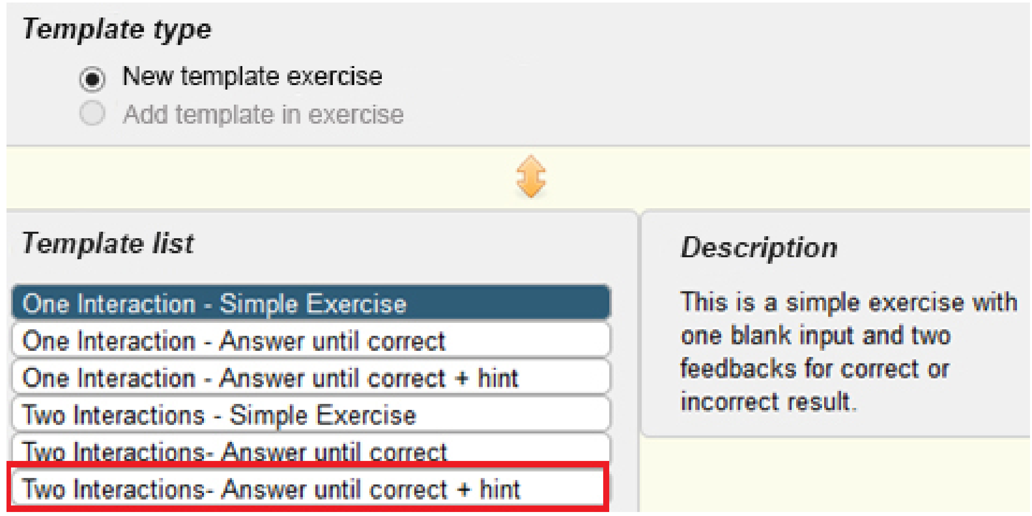


Fig. 2. Template types to design exercises



in training students from different majors. Separate units and templates used in algorithm design make it possible to model a trajectory of incremental problem solving with hints as an option in case of student's wrong answer. Such approach helps students to enrich and use their knowledge while working with dynamic objects of Math-Bridge system. These methods are particularly effective in training students on using different methods of array sorting: insertion sort, selection sort, and exchange sort (bubble sort).

The capacity of Math-Bridge system can be shown by the example of exchange sort, one of the simplest sort methods. The idea of the algorithm is to compare two adjacent elements. If their position does not comply with the set sorting conditions, they are interchanged. Then, the next two elements are examined until all the elements are sorted. In other words, it is necessary to develop the training trajectory that would allow testing and adjusting student's knowledge at each step of intermediate array formation.

Let us consider the training trajectory implementation via a dynamic element of Math-Bridge system. It is an exercise based on the template «Two Interactions – Answer until correct + hint» (fig. 2) and additional units (fig. 3)

As fig. 3 shows, the training trajectory has 4 interactions with a trainee, presented by units "Task1-Task4" that contain tasks for the next iteration of external srting cycle. The units "Interaction1-Interaction4" contain 4 options of the answers, one of which is the correct reflection of the array after each sorting stage. The next unit is available if a trainee chooses the correct option.

Fig. 4 shows an adjustment menu for branches. It enables an instructor to attribute a number of grades for a particular answer.

If a trainee chooses the correct option at each stage, he/she finally has an array correctely sorted. In this case, the next branch is switched to the ways shown by green arrows (fig. 3). If the trainee's choice is wrong, the system gives an error message and a hint, which is brief information about sort algorithm, it also offers to choose the corrct option (fig. 5).

Thus, the required skills are trained while studying the algorithm of exchange sort. The advantage of such exercise concept is the opprtunity for trainees to identify their errors, correct them, and avoid repeating them again, by revising theoretical base

Fig. 3. Training trajectory via template "Two Interactions – Answer until correct + hint" – 1 and additional units – 2

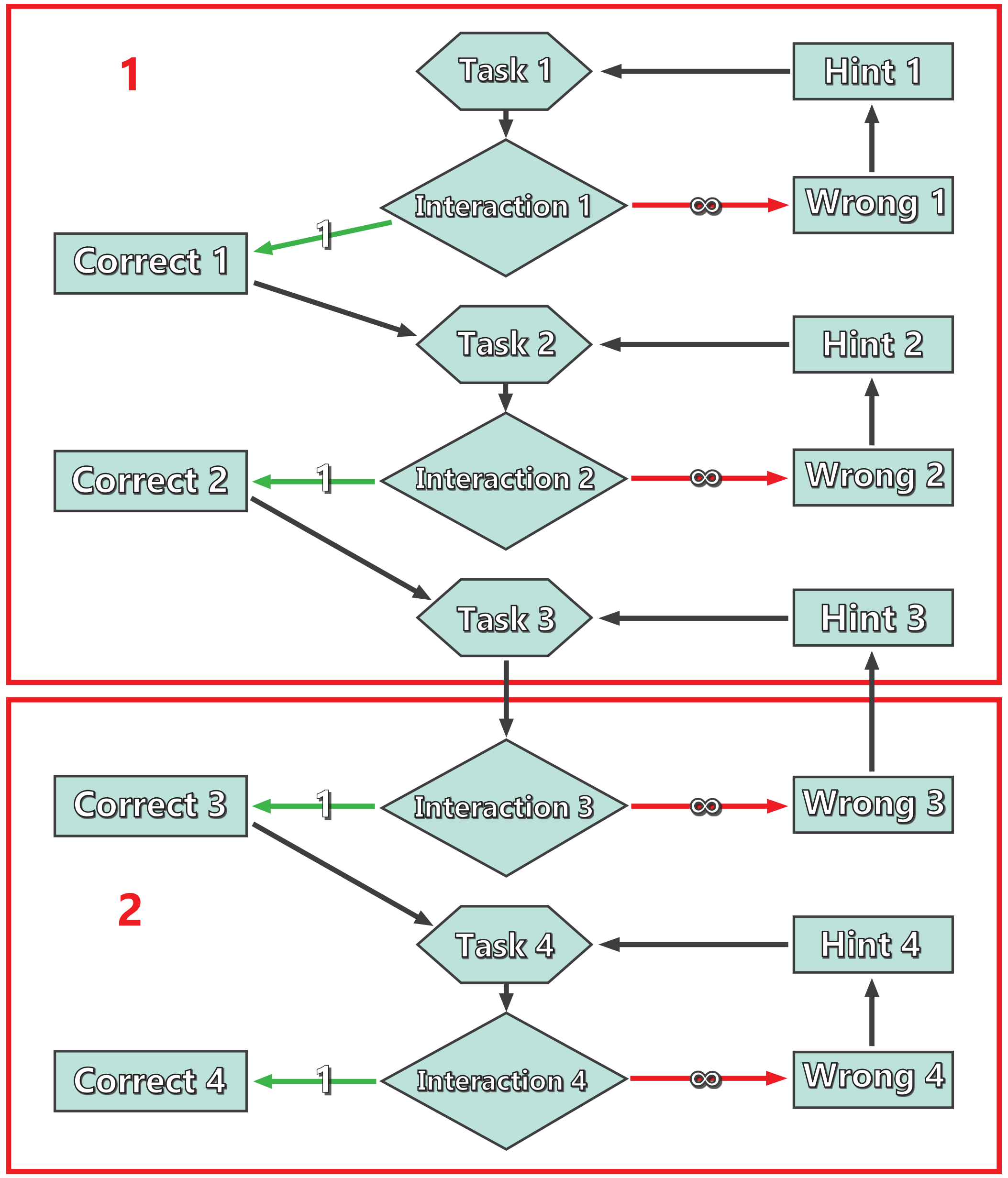
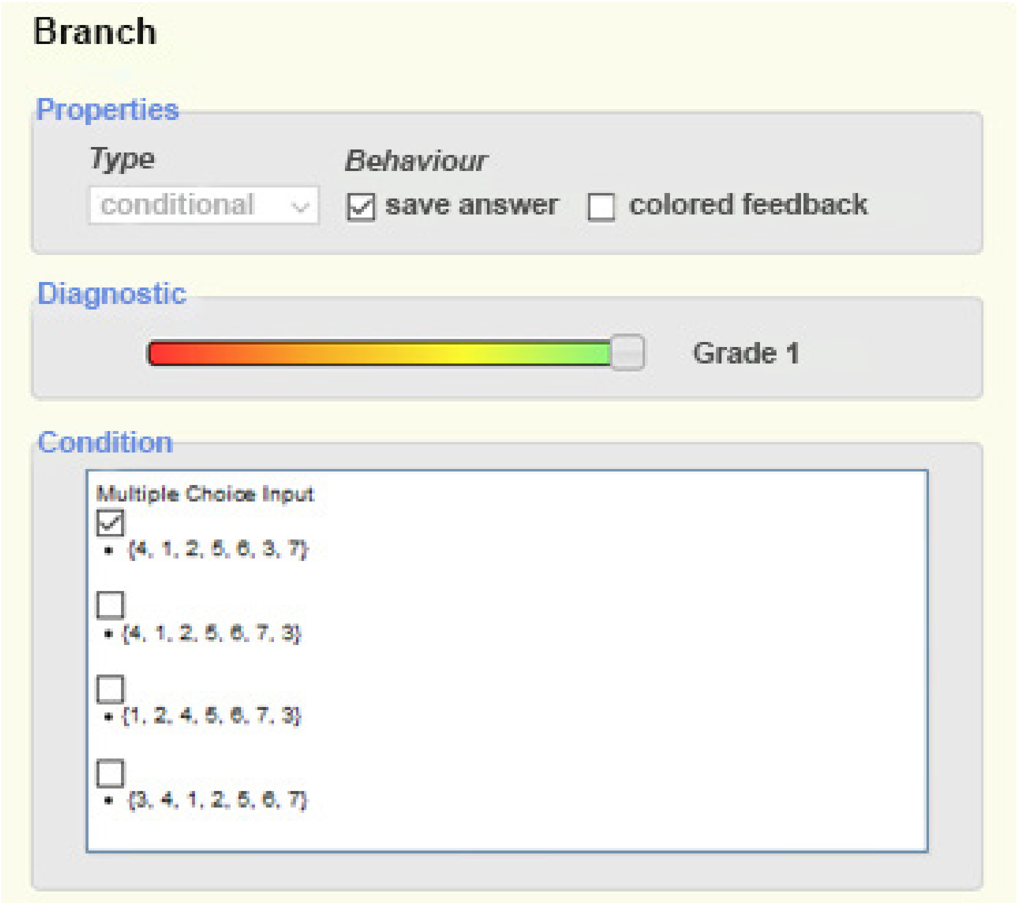


Fig. 4. Menu to adjust evaluation at the first training stage



provided by Math-Bridge system in the hint form.

The same exercise, without hints though, can be used only to control students' skills and knowledge. It is also possible to adjust the system to the mode prevents continuing the exerciseif the traineeo = has chosen a wrong option.

Fig. 6 shows a structure of a trajectory applied to control learning outcomes. Units "2" and "-2" cannot be distinguished, their contents are identical. They present the second sorting stage. The difference between them is that unit "2" is a link in the chain of correct answers, while unit "-2" belongs to the chain of wrong answers. There is no unconditional switch to the next interaction unit, which is a specific feature of the system. Thus, it is necessary to double the units of wrong answer branches, starting from unit "3".

Fig. 6 proves that the final correct answer can only be obtained by choosing the correct answer at each stage of the exercise. If a trainee makes a mistake at least in one unit, he/she is referred to the part of the algorithm with the units having the same content. However, there will be no shift to the branch of correct answers, no matter if the answer is right or wrong.

To sum up, it should be noted that versatility is an advantage of Math-Bridge system. This experience can be applied to sorting arrays of any size. The difference is in the number of units and content adjustment.

Fig. 5. Error message and brief explanation

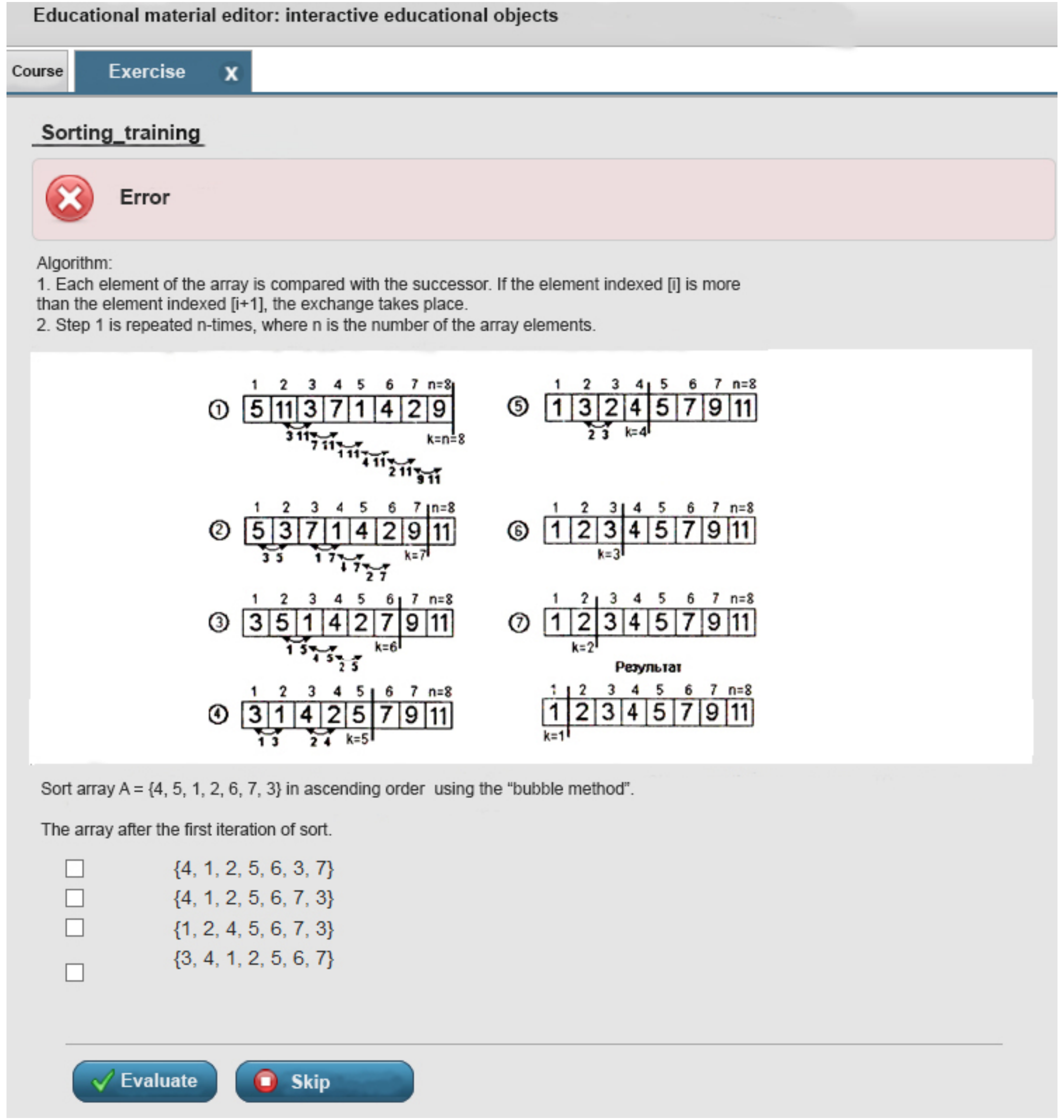
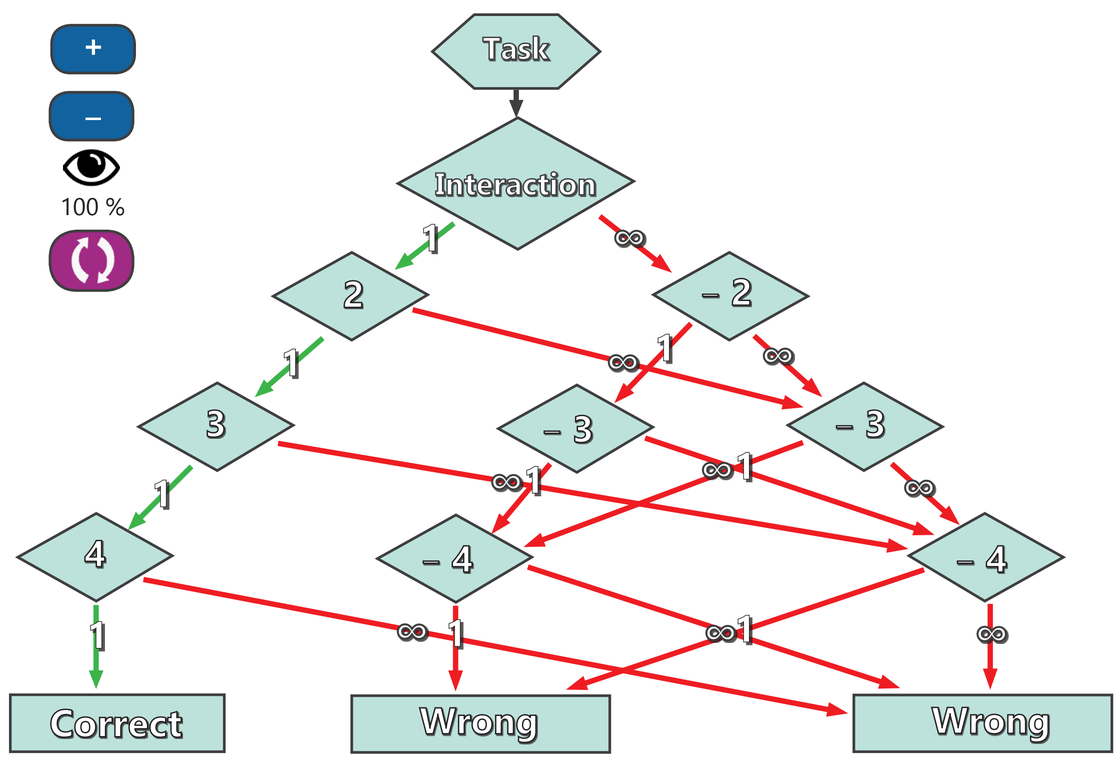


Fig. 6. Trajectory of learning outcomes control via units



REFERENCES

1. Sosnovsky S., Dietrich M., Andrиs E., [et al.] Math-Bridge: Bridging the gaps in European remedial mathematics with technology-enhanced learning. Mit Werkzeugen Mathematik und Stochastik lernen = Using Tools for Learning Mathematics and Statistics. Berlin/Heidelberg: Publ. Springer, 2014, pp. 437–451.
2. Galeev, I.Kh. Problemy i opyt proektirovaniya IOS [Elektronnyi resurs] [Challenges and experience of IES design]. Obrazovatel'nye tekhnologii i obshchestvo [Educational technologies and society]. 2014, Vol. 17, no. 4, pp. 526–542. URL: http://ifets.ieee.org/russian/depository/v17_i4/pdf/9.pdf, (Accessed 12.12.2016).
3. Sosnovskii S.A., Girenko A.F., Galeev I.Kh. Informatizatsiya matematicheskii komponenty inzhenernogo, tekhnicheskogo i estestvennonauchnogo obucheniya v ramkakh proekta MetaMath [Elektronnyi resurs] [Informational support of mathematica components of engineering, technical and scientific training in the frame of MetaMath project]. Obrazovatel'nye tekhnologii i obshchestvo [Educational technologies and society]. 2014, Vol. 17, no. 4, pp. 446–457. URL: http://ifets.ieee.org/russian/depository/v17_i4/pdf/1.pdf, (Accessed 12.12.2016).
4. Zakharova I.V., Kuzenkov O.A., Soldatenko I.S. Proekt MetaMath programmy Tempus: primenenie sovremennykh obrazovatel'nykh tekhnologii dlya sovershenstvovaniya matematicheskogo obrazovaniya v ramkakh inzhenernykh napravlenii v rossiiskikh universitetakh [MetaMath project by Tempus: modern educational technologies to enhance mathematical training in engineering universities in Russia]. Sovremennye informatsionnye tekhnologii i IT-obrazovanie [Modern Information Technologies and IT-Education]. 2014, no.10, pp. 159–171. (In Russ., abstr. in Engl.).
5. Savkina A.V., Nushtaeva A.V., Boriskina I.P. Informatizatsiya kursa "Algebra i geometriya» s pomoshch'yu intellektual'noi obuchayushchei sistemy Math-Bridge [Elektronnyi resurs] [Informational support of "Algebra and Geometry" course via Math-Bridge smart system]. Obrazovatel'nye tekhnologii i obshchestvo [Educational technologies and society]. 2016, Vol. 19, no.4, pp. 479–487. URL: http://ifets.ieee.org/russian/depository/v19_i4/pdf/18.pdf, (Accessed 12.12.2016).
6. Savkina A.V., Savkina A.Vl., Fedosin S.A.. Virtual'nye laboratorii v distantsionnom obuchenii [Elektronnyi resurs] [Virtual laboratories at distant learning] Obrazovatel'nye tekhnologii i obshchestvo [Educational technologies and society]. 2014, Vol. 17, no. 4, pp. 507–517. URL: http://ifets.ieee.org/russian/depository/v17_i4/pdf/7.pdf, (Accessed 12.12.2016).
7. Novikova S.V., Valitova N.L., Kremleva E.Sh. Osobennosti sozdaniya uchebnykh ob"ektov v intellektual'noi sisteme obucheniya matematike Math-Bridge [Elektronnyi resurs] [Design of educational objects in Math-Bridge smart system in math training]. Obrazovatel'nye tekhnologii i obshchestvo [Educational technologies and society]. 2016, Vol.19, no. 3, pp. 451–462. URL: http://ifets.ieee.org/russian/depository/v19_i3/pdf/7.pdf, (Accessed 12.12.2016).

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Educational Technologies in Engineering Education: Multidisciplinary Approach

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The article discusses the issue of implementation of multidisciplinary approach in engineering education through the construction of modular educational programmes, the implementation of network forms of education, as well as the use of interactive learning technologies. It is emphasized that the use of interactive technologies in the learning process is the first step in the implementation of interdisciplinarity on the level of educational programmes content aiming to foster competences of a future engineer.

Key words: interdisciplinarity, engineering education, interactive educational technologies, CDIO, case studies, competence-based approach.

Education is not a sum of knowledge, but a full understanding and a skillful application of everything you know.

A. Disterveg

It is still common for universities to teach courses discretely with no connection to one another. Such approach provides knowledge, but not understanding. By receiving the scientific knowledge specifically students, in most cases, barely understand how and to what extent this knowledge can be interconnected.

The so-called monodisciplinary method of teaching and learning, which is familiar and seems to be an essential part of the whole system of higher education, tends to be less and less efficient.

The interdisciplinary character of the modern learning is, to a great extent, determined by the fact that science transforms from a "disciplinary" area of action to a "problem-oriented" one.

It seems that today and in the future only those specialists, who learn to understand the interdependence and consistency of the world and perceive each specific science as a sphere or a subsystem of an ultimate bigger system, will achieve success.

Interdisciplinarity in a broad sense represents a method for enriching scientific mindset residing in exploration of a certain phenomenon without the limitation to one specific scientific discipline [5].

In this sense, one of the directions for the implementation of interdisciplinarity in engineering education is module design of educational programmes. By joining disciplines over a certain research subject it is possible to build an organizational and procedural interdisciplinary structure of study materials that consists of a set of topics from various disciplines essential for a particular study programme.

A module can be formed from several related disciplines that assure module's interdisciplinarity and are aimed at the formation of a wide spectrum of necessary competences, which, it their turn, lie outside of the module's scope [2, 7].

Thus, the interdisciplinary approach strives to use a holistic picture of a research subject, where all the disciplinary pictures are seen as its parts [3].

Another direction for the development of interdisciplinarity in training of engineers lies at the root of a specific form of study programmes realization – a network form.

According to paragraph 15 of the Russian Federation Federal Law on Education [6], a network form of realization of study programmes provides an opportunity for programmes mastership by the use of resources of several organizations that conduct educational activity, including foreign ones, as well as by using resources of third-party organizations, if needed.

Therefore, one of the main characteristics of a network form of engineers' training is the application of this form of training for prospective (unique) study programmes, which, as a rule, have interdisciplinary nature for the purpose of training workforce for large industry-specific, scientific or other types of projects.

For the realization of such industry-specific programmes aimed at training of highly qualified engineers in prioritized areas of field-specific, inter-field or regional development based on international educational and professional standards, the HEIs introduce educational and industrial centers and departments, including industrial departments, design units and industry-oriented innovative technological centers. In other words, HEIs create laboratory and production facilities for joint training.

A distinct context is given to the idea of interdisciplinarity in the framework of competence-based approach to education. The main aim of this approach is to foster a set of competences, rather than certain stand-alone knowledge, skills and attitudes. Objectives of the educational process in this approach consider the methods of thinking and acting rather than the disciplines themselves.

The most prospective way to enhance the quality of engineering training is to change teaching and learning methods, specifically to introduce interactive technologies.

Interactive technologies are focused on a broad interaction of students with teachers and with each other in the process of acquiring professional knowledge and skills [1]. The distinctive feature of these technologies is the development of students' personal initiative, fostering of strive for gaining new knowledge and skills, which lies at the root of the competence-based and student-oriented approaches in education.

The examples of interactive technologies are: case study, project method, computer simulation, discussions and other.

According to the CDIO Standard 8, learning should be based on active practical approach, which aims to interest students in generation, analysis, evaluation and application of ideas. This can be put into action by means of active teaching and learning methods.

However, while the active methods are firstly aimed at active interaction of students with a teacher, interactive technologies also anticipate students' interaction with one another.

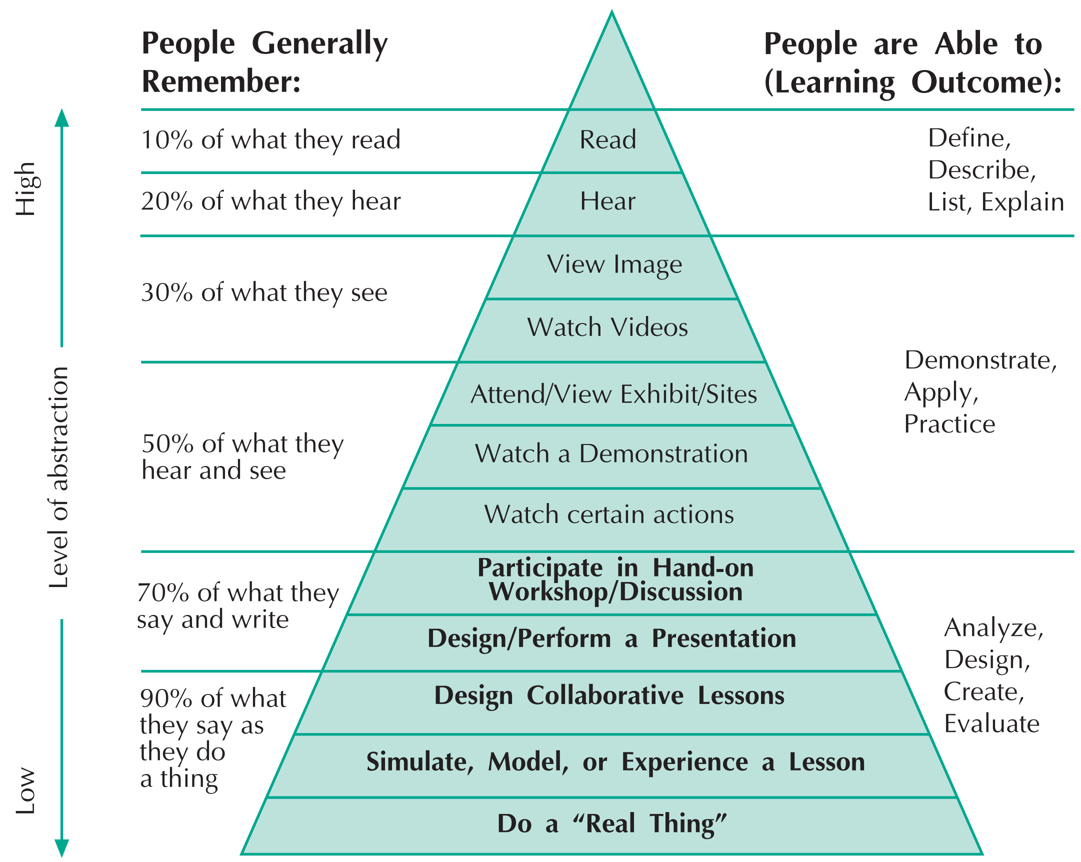
Based on the research of Edgar Dale on the connection of training methods and students' ability to apply the information received, a so-called Dale Cone has been structured (fig. 1).

According to the Dale Cone, listening to lectures or reading materials on a certain course are the least efficient methods for learning anything; teaching others and applying the material learned to real life are the most efficient learning methods.

Although one question is still in order: how do interactive technologies ensure the realization of interdisciplinary approach?

Interactive technologies, as has been stated above, are focused on the interaction between students and teachers, as well as between students themselves. It is only within an activity that we can evaluate the level of competences' formation as learning outcomes of a study programme. At this, each study programme consists of a set of disciplines (modules), internships and final state attestation (further – programme elements). Learning outcomes are planned for each element of a study programme. These outcomes are connected with the level of knowledge, skills, attitudes and expertise that characterize stages of competences' formation and ensure the achievement of the expected learning outcomes. In other words, competences (soft skills, general professional

Fig. 1. Dale Cone of Experience



competences and specific professional competences) are formed in the process of learning several elements of a programme, and the procedure of their evaluation covers the contents of several disciplines (modules) and internships. Consequentially, this ensures the realization of interdisciplinary approach in the framework of using interactive teaching and learning methods.

One of the most efficient interactive teaching and learning method from the point of future engineers' competences formation is the method of case study.

Case study is an interactive teaching and learning method that uses portrayal of real economic, social, day-to-day and other problem situation. When working with cases students conduct search and analysis of extra information from different areas of knowledge, including the ones connected with their future professions.

"The essence of this method is that students are asked to interpret a real-life situation. The description of a problem covers not only a practical problem, but also refreshes a certain set of knowledge, which should be acquired while solving a problem. The problem itself does not have an unambiguous solution." [4, pp. 10].

In the framework of a case study a problem and its ways of solution are formed based on a set of data (a case) with a diverse description of a situation from various sources: scientific, special literature, popular science journals, mass media, etc. Cases include unambiguous information on a specific problem. Such cases are at the same time both a task and a source of information for understanding different designs of efficient actions.

The article discloses an example of a case study, which has been delivered to the students of Saint Petersburg branch of Demola (a Finnish project).

The task described in the case was to create a cheap and efficient fire alarm system for "smart houses".

The team of students working on the case included: Ilya Odnokolov (Saint Petersburg Electrotechnical University), Anastasiya Barzakovskaya (Peter the Great St. Petersburg Polytechnic University), Roman Antonov (ITMO University).

After two month of work, the team has proposed a solution: a fire alarm signaling device consisting of a sensing system that registers data on temperature, humidity and smokiness of a home and sends the data to a server. In case of an off-standard situation, the owner of a "smart home" receives notification on his/her phone.

The practical focus of such tasks allows applying theoretical knowledge to solving practical tasks. Case studies compensate for an entirely academic education and provide a wider view on the future profession.

Interactive form of cooperation between students ensures a more efficient mastership of study material due to a high emotional involvement and active participation of students. The emphases are put on acquisition of a ready-made knowledge, and not on its development.

Teamwork allows enhancement of soft skills: responsibility, communication skills, stress resilience, critical thinking, time management and financial management, etc.

Being an interactive technology, a case study, as seen from practice, arouses positive attitude among students, who see it as a "game" ensuring mastering of theoretical contents and acquiring experience of practical application of learned material.

This teaching and learning technology has been compared with the Educational Standard 12.03.05 Laser Technology (which is true for a study programme of one of the ITMO University students, who worked on the case mentioned above) from the point of assessing competences' formation. The comparison shows that case studies directly form at least 4 competences: an ability to work in a team, an ability to tolerate social and cultural differences; an ability to process and present experimental research data; an ability to conduct search, maintenance and analysis of information from various sources and databases, to present it in a required format by using information technologies, computer and network technologies; an ability to develop optimum solution, while creating products of professional equipment in compliance with the requirements on quality, price, time limits, competitiveness and safety, as well as environmental safety.

Thus, introduction of the interactive technologies to the training process of future engineers allows not only to ensure interdisciplinarity, but also to integrate interdisciplinary ties on a higher level of complexity.

The first two methods (the modular and network forms) of the realization of interdisciplinary approach refer to the design of study programmes based on transformations of the structure of main professional educational programmes and require a significant alteration of the whole programmes, whereas the last method – introduction of interactive teaching and learning methods – in this sense is less intrusive. It allows executing interdisciplinary connections even within a linear disciplinary study programme, thus it can be considered to be a first step towards the realization of interdisciplinary approach in engineering education.

However, it is possible that an active use of interactive teaching and learning methods would provoke inner transformations of programmes by means of interdisciplinary connections and evaluation tools, which would naturally lead at least to a modular structure of study programmes, if not to a network one, since a student needs to go from an area of knowledge to an area of action and life purposes in order to become a professional engineer.

REFERENCES

1. Dvulichanskaya N.N. Interaktivnye metody obucheniya kak sredstvo formirovaniya klyuchevykh kompetentsii (Interactive Teaching Methods as Means for the Formation of Key Competences) [Electronic resource] // Nauka i Obrazovanie (Science and Education of Bauman MSTU). – 2011. No. 04. – URL: http://technomag.edu.ru/doc/172651.html, free. – Tit. from the screen (usage date: 09.12.2016).
2. Ermolenko V.A. Blochno-modulnaya systema podgotovki spetsialistov v professionalnom litsee (Block-Modular System for Training Specialists at Professional Lyseum) V.A. Ermolenko, S.E. Dankin. – Moscow: TsPNO ITOP RAO, 2002. – 162 p.
3. Transdistsiplinarnost v sovremennoi nauke (Transdisciplinarity in Modern Science) [Electronic resource] // Psikhologos: entsiklopedia prakticheskoi psikhologii. – 2009–2016. – URL: http://www.psychologos.ru/articles/view/transdisciplinarnost_v_sovremennoy_nauke, free. – Tit. from the screen (usage date: 09.12.2016).
4. Situatsionnyi analiz ili anatomiya keis-metoda (Situational Analysis or the Anatomy of Case-Study Method) / Yu. Surmin [et. al.]. – Kiev: Center of Innovations and Delopment, 2002. – 286 p.
5. Universalnaya entsiklopedia (Universal Encyclopedia) – http://unienc.ru/w/ru/86300-mezhdistsiplinarnost.html
6. On Education in Russian Federation [Electronic resource]: Federal Law No. 273-FZ of 29 December 2012 (as amended on 15 July 2016). – Available from information and reference system "Kodeks".
7. Shamova T.I. Upravlenie obrazovatelnymi processami (Management of Educational Processes) / T.I. Shamova, T.M. Davydenko, G.N. Shibanova. – Moscow: Akademia, 2002. – 384 p.

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Interdisciplinary Project – Basis for Designing Study Programmes

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The specifics of engineering activity lie at the root of projects' implementation. An ability to independently develop and implement projects, as well as to assess their impact and significance is a necessary competence of each graduate. Thus, the core component of training competitive specialists is the introduction of interdisciplinary projects to the learning process. These projects are discussed in the article as a basis for designing of professional study programmes for higher education.

Key words: interdisciplinary project, engineering education, design of study programmes, project- and practice-oriented education.

The topic of interdisciplinarity is not new to the area of engineering education. It has been addressed repeatedly in the development of main professional educational programmes and in execution of fundamental and applied scientific research. The main aim of introducing interdisciplinarity is to obtain a new and novel product as a response to modern challenges of science and society.

The CDIO Initiative raises a question of the need for the formation of educational programmes that include interconnected disciplines, where training intends fostering an ability to create products, processes and systems, communication skills and personal development skills. Students should receive wide experience of conducting design and experimental activities within the training process both in classrooms and in modern training laboratories. Training should be based on exploring engineering activities in line with the model "Conceive – Design – Implement – Operate" real systems, processes and products on international market (CDIO model) [1].

The criteria and procedure of the professional accreditation of educational programmes have been developed by the Association for Engineering Education of Russia (AEER) with an aim to assess the quality of engineering specialists' training in higher education institutions and vocational schools. These criteria state that "the basic knowledge of design in the context of uncertain and controversial requirements, the abstract thinking skills and ability to analyze complex multicomponent problems that do not have a single-valued solution are essential for comprehensive engineering activities"; a student "has to be ready to manage interdisciplinary projects, to have a grip on the principles of management, to conduct efficient communication within society and professional communities. At the same time he/she is required to be able to solve technical tasks with regard to legal and cultural aspects, safety and health precautions, to understand the responsibility for the decisions made" [2].

The foresaid determines the need for new approaches to the development of main professional educational programmes for higher education. The authors disclose interdisciplinary educational projects as one of such approaches. While developing main professional educational programmes the transition from course/discipline (knowledge-based) organization of educational process to a block-modular, project-based and practice-oriented, person-based, result-oriented organization is

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performed. This transition is ensured by the development of own educational standards at ITMO University (ITMO Educational Standards).

Study programmes of Bachelor level, developed based on the ITMO Educational Standards provide basis for innovative training of globally competitive specialists by creating educational environment that ensures the choice of educational paths and training methods, the access to corporate and personal knowledge databases, including databases formed by students, the choice of training pace, the attraction of a wide range of experts from science, business and industry.

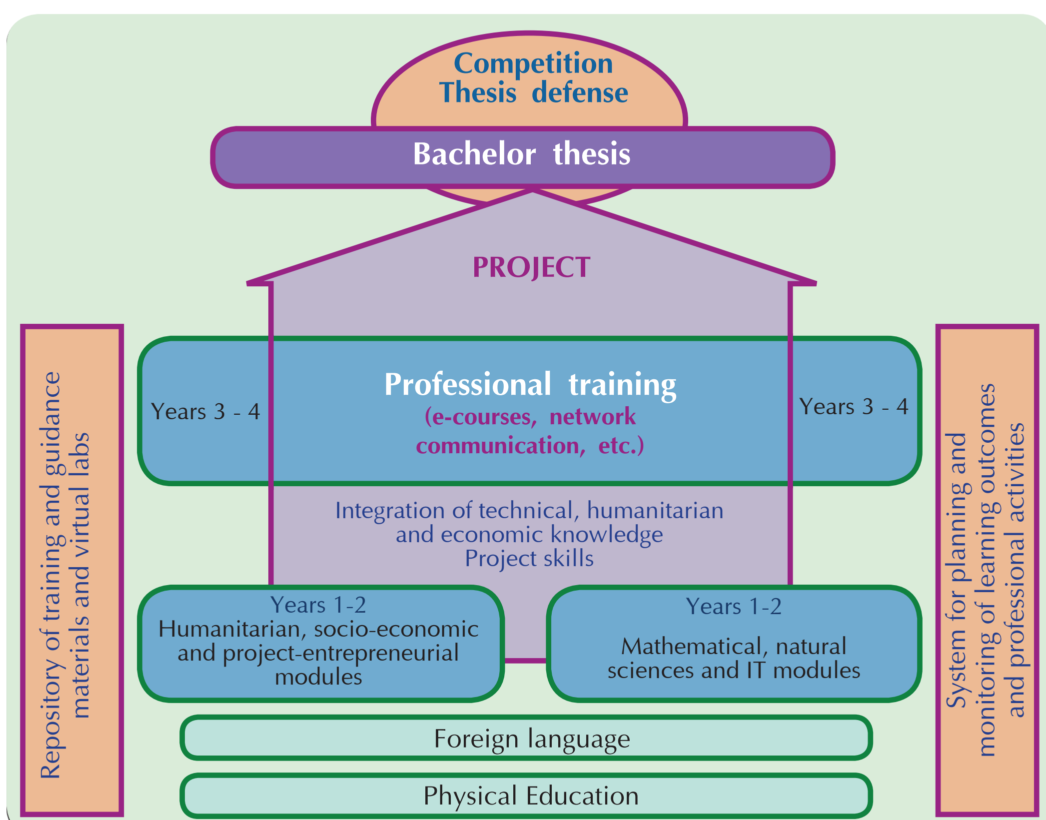
Problem and project training is a conceptual pillar of the training process that can be built upon conducting real projects.

Framework of development concept for Bachelor Educational Standards is presented in the scheme (fig. 1).

The formation of the basic educational block is based on the block-modular principle and includes the following educational modules:

- Humanitarian module, including mandatory disciplines, such as history, philosophy and other disciplines of the humanities focused on the formation of an ability to analyze information and ideas and to formulate problems.
- Socio-economic module focused on the formation of communication skills, economic, legal and juridical competences.
- Project and entrepreneurial module, including disciplines aimed at acquiring knowledge on project management,

Fig. 1. Module and project-oriented training of bachelors based on interdisciplinary projects



management of innovative projects, decision making for practical scientific and technological problems and tasks. This module provides broad and deep training for task-oriented professional activity essential for fostering an ability to understand professional and ethical responsibility.

- Foreign module aimed at the formation of communication skills in both oral and written communication in foreign language for solving tasks of interpersonal and intercultural cooperation.
- Module of natural sciences, IT and math, that provides fundamental training and creates basis for training graduates with required professional competences, including those aimed at application of information technologies and professional packages. The main objective of this module is to foster practical skills of applying mathematical and physical phenomena in professional activity, as well as while studying major-specific disciplines and executing projects.
- General professional module that includes health and safety courses, as well as disciplines aimed at formation and development of general professional competences.

Fundamental training on math and natural sciences, as well as integration of technical and humanitarian knowledge for realization of socially important projects is conducted during 1st and 2nd years of bachelor programmes. The study process includes modules and disciplines on development of professionally-oriented programmes, such as "Introduction to Project-based Activity", "Introduction to Engineering", and programmes of academic and social adaptation – "Adaptation to learning", "Practical psychology of a student", etc.

Besides the usual curriculum students can participate in summer and winter language and theme schools, seminars and workshops on personal development and socialization of students.

During the 3rd and 4th years of bachelor programmes training is based on an active introduction of problem-based and project-based learning, studying principles of managing innovative projects and main stages of products' and processes' life cycles, as well as team-work skills and elements of entrepreneurship. Students conduct interdisciplinary problem-oriented scientific research (design) projects within study process by participating in research activity of their departments or research educational centers.

The curriculum includes modules of students' professional training for innovative and entrepreneurial activities, such as "Project Management", "Management of Innovations", "Engineering Entrepreneurship" and other that foster research and entrepreneurial skills and leadership. Through the project work students contribute materials for their future bachelor thesis. At the end of the project period a competition of students' projects is held; winning projects are proposed to be implemented and their creators are recommended for the enrolment to master programmes.

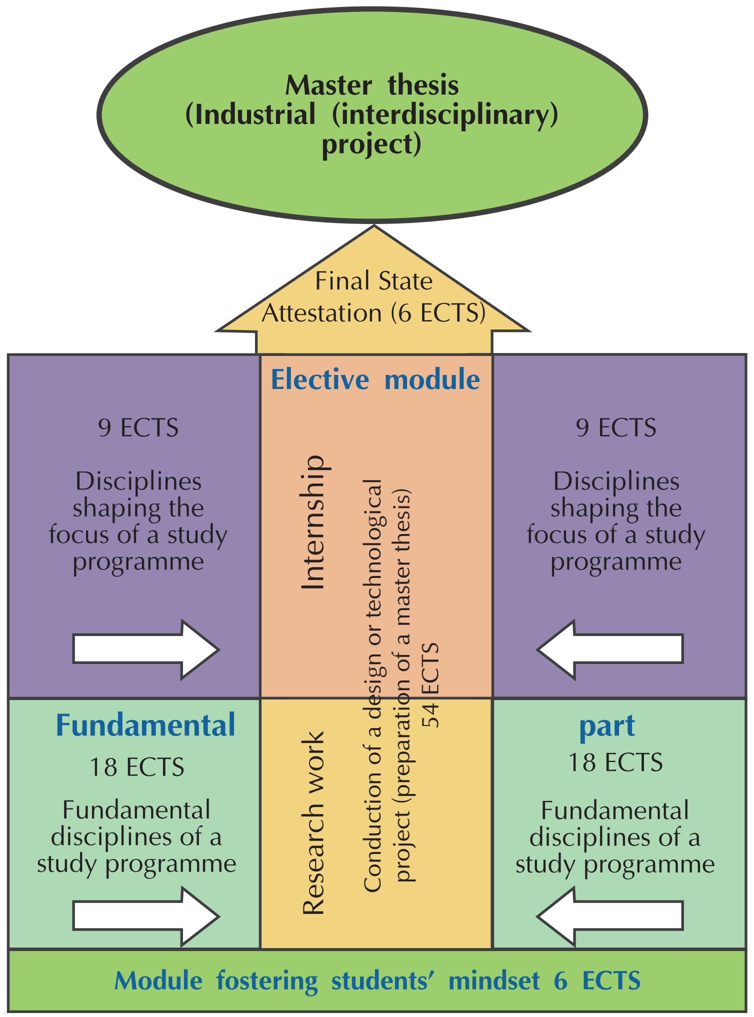
Framework of development concept for Master Educational Standards is presented in the scheme (fig. 2).

Master programme curriculum includes the following modules supporting interdisciplinary projects: module fostering students' mindset (6 ECTS), general professional module (18 ECTS), professional module (18 ECTS), and elective module (18 ECTS). The rest of the curriculum (60 ECTS) is devoted to the conduction and the defense of an interdisciplinary project in the process of internship, research work and final state attestation.

This approach to bachelor and master programmes curriculum design corresponds to the international CDIO Standards with regard to studying products' lifecycle stages, increasing the percent of practical studies, acquiring design and implementation expertise.

A system of joint project work and problem-based learning is supported by e-learning and distant learning technologies, which assure students' immediate access

Fig. 2. Framework of development concept for Master Educational Standards



to the required databases that might be needed within the process of project work. In order to work in real time conditions and to acquire new knowledge on project theme students need to have access to a well-structured and constantly updated electronic database. Such database should also be filled by students themselves. The university's system of distant learning provides students with access to a database of university's e-courses, as well as courses of other partner universities, including foreign ones.

According to the chosen learning path a student can choose courses that he/she has interest in. The control of learning outcomes is conducted through a system of planning and monitoring of learning outcomes and professional achievements, which allows developing students' soft skills and their motivation, as well as managing their study process. Students can receive credits for any discipline or course that can be accessed. Personal results of every student's staged training are recorded in the learning outcomes database.

With an aim to enhance the quality of students' training, their competitiveness and motivation, and programmes resourcing study programmes can be executed in a network form. At this, particular disciplines can be studied at leading Russian or foreign universities based on academic mobility of students in line with the agreements for network study programmes. The contents, volume and study periods of partner universities' programmes indicated in such agreements.

Thus, the main specifics of the development of bachelor and master programmes (in the framework of interdisciplinary projects realization) are as follows:

- Consideration of educational standards (Federal State Educational Standards, university and international standards) and Professional Standards;
- Theses, course projects and self-study tasks should be tightly connected to real projects executed by scientific and industrial organizations;
- Students acquire up-to-date knowledge and abilities, foster personal skills (also by gaining responsibility for their results) by conducting independent search for project solutions and receiving expert evaluation from teachers, employers and theirs fellows.

REFERENCES

1. Worldwide CDIO initiative. Standards: guidance / translated from English into Russian by A.I. Chuchalin, T.S. Petrovskaya, Ye.S. Kulyukina; Tomsk Polytechnic University. – Tomsk, 2011. – 17 p.
2. Kriterii I protsedura professionalno-obshestvennoi akkreditatsii obrazovatelnykh programme po tekhnicheskim napravleniya i spetsialnostyam: informational edition / S.I. Gerasimov, A.K. Tomilin, G.A. Tsoi, P.S. Shamritskaya, E.Yu. Yatkina; edited by A.I. Chuchalin. – Tomsk: Tomsk Polytechnic University, 2014. – 56 p.

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Virtual Labs in Engineering Education

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The article deals with the use of virtual labs in engineering education. The programmes which allow simulation of electronic circuits and robotic systems have been considered. The analysis is based on the use of virtual labs in the distant course "Practical engineering education" for pupils. The programme is designed by the authors.

Key words: virtual laboratory, simulation, microcontrollers, circuits, robots.

Introduction

In spite of the growing labour market demands for engineers of new generation, among the applicants' preferences there is still a shift towards juridical, economic, and managerial specialities. Therefore, one of key tasks nowadays is to promote engineering education. This task is necessary to be resolved even at school level at the time when a pupil develops his/her preference for future profession.

Apart from programming taught as a part of informatics, there is a lack of engineering subjects in the school curricula that causes the situation when applicants are not prepared for engineering study at university, which leads to the decrease in students' academic performance, growth of expulsions and transfers to humanity departments [1]. Therefore, low level of pupils' engineering knowledge decreases popularity of engineering jobs, as the applicants do not want to enter and study at engineering universities.

All these condition the urgency of developing supplementary educational programmes for practice-oriented research-engineering clubs of engineering art for senior pupils and junior students aimed at involvement of youth in the engineering creativity, development of engineering thinking, and, as a consequence, motivation of choosing engineering profession.

Nowadays, diverse online courses have gained great popularity, as they provide an opportunity of learning at home, at any time, with the playback option learning material repeatedly. Such courses enable to acquire the necessary skills at minimal cost for the students simultaneously developing necessary competencies. However, with regard to the issue of engineering education, there is a problem of lack of necessary equipment. Courses of engineering art, particularly if it involves electrical engineering and robot design, are senseless without practical classes, which, in their turn, require special laboratory equipment. How, for example, to learn to design robots without necessary materials?

To solve this problem, one can use a virtual laboratory. They allow emulation of practical tasks to draw a circuit, programme a microcontroller, and even design and programme robots with high degree of confidence.

The present article gives the review of contemporary learning techniques and considers their application in full-time and distance courses on engineering design. The review is based on the authors' experience gained in designing the distance course "Bases of practical engineering modeling" intended for pupils in the course of the state project of the RF Ministry of Science to arrange practice-oriented research-engineering communities of engineering art.

Simulating electronic microprocessor-controlled circuits

Using microcontrollers in electronic circuits ensures the sufficient increase in solution flexibility and decrease in its design

complexity, hence, its cost. This fact served as a starting point in wide application of microcontrollers in the field of electronics. For example, even such a simple device as a lantern can be microprocessor-controlled. Therefore, the issue of learning electronic circuit development is now closely connected with the problem of microprocessor application.

As far as the authors know, at present there is only one free system, i.e. virtual laboratory for simulating electronic circuits controlled by microprocessor. This is an online service circuits.io [2] (fig. 1).

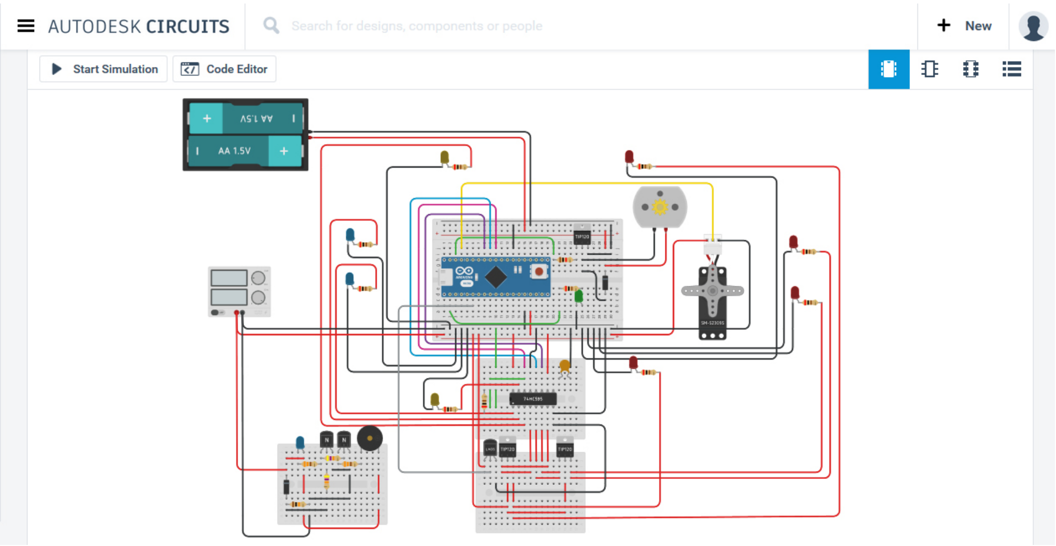
As this system functions on-line, its application does not imply installation of additional software – all operations are performed directly in browser. It should also be noted that software is well compatible with old computers (e,g., the software was successfully tested by the authors using notebook with Intel Core i3 380M processor produced in 2010). Hence, one can say that the software is highly accessible.

The virtual laboratory allows for development of electronic circuits using a wide set of components including current and voltage sources, passive components (resistors, condensers, and inductors) and active components, such as diodes, transistors, operating amplifiers, micrologic units, various sensors, and displays. In addition, the interface of user's operation with components is fully supported, as one can turn a potentiometer during simulated circuit operation, which results in alteration of its resistance and is taken into consideration in model operation; change the temperature, which is measured by temperature sensor etc.

The primary mode of designing electronic circuits is a breadboard mode, at which the components are arranged and connected. There is also a view mode (without editing) of principal electrical circuit, which is automatically composed with connection to breadboard. Besides, editor board is provided to trace printed circuit board and export the result of the standard Gerber format supported by nearly all printed circuit board equipment.

However, the highlight of circuits.io environment is an emulation support for microprocessor control. The environment has Arduino board and Atmel microcontrollers as well as restores their programming instrument of Arduino board. Thus, students have an opportunity to develop electronic

Fig. 1. Virtual laboratory circuits.io



circuit, microcontroller programme, and model programme circuit interaction.

It should be noted that Arduino board is often criticized in professional community [3]. The experts mainly criticize the programming style of Arduino environment, which is not consistent with the industrial microcontroller software style and prevent from achieving maximum efficiency in using available resources.

Nevertheless, the authors suggest Arduino platform to be well suited for learning fundamentals of embedded system design, since comparatively low knowledge is required to obtain first practical results. This feature facilitates further study of more complicated development techniques.

To specify the problems of Arduino programming and show the ways of its development are the tasks which have to be taken into account in developing courses on circuits.io and Arduino environment.

The use of Arduino also allows students to easily turn from virtual experiment to practice – Arduino bound is cheap and does not require additional equipment except USB cable.

The disadvantage of circuits.io board is an absence of sensors with digital interface. Arduino model is fully supportive of i2C interface, whereas only other types of Arduino can be used as a device for connection. On the one hand, this option allows learning the operation of i2C bus in both master and slave modes. On the other hand, digital sensors are now widely used, but the lack of support reduces the scope of its functions that could be performed at the courses based on this board.

On the whole, it is necessary to underline that circuits.io service can efficiently be used to develop courses on circuits engineering and embedded system design, allowing the entire cycle of a unit design including development of electronic circuit, software debugging, and PC board layout.

Robot simulation

The capacity of circuits.io system is limited due to simulation of electric component – it can show how propeller is rotating on a motor or servodrive is rotating, but it does not provide simulation of their interaction with the physical environment. It is an exclusive province of other programmes intended for robotic system simulation.

Based on the preliminary analysis the authors have distinguished three existing systems that can be used in education as virtual laboratories: ROS, Webots, and V-REP.

ROS system

ROS (Robot Operation System) [4] is a platform to design robots, which was developed by the experts of Stanford University. It is the only fully free system with open source software among the three mentioned above. ROS system was developed as a core for implementing robotic software and, together with other components developed in this environment, such as Gazebo emulator [5], can be used as a virtual robotics laboratory.

The main disadvantage of ROS is that only specific versions of necessary software package can be installed in Ubuntu operating system. Numerous Internet sources considering this system describe its installation and solution of arising problems of environment and component compatibility. This solution cannot definitely be recommended for school online courses, as the most part of pupils are not able to install it.

Webots System

Webots design environment [6] was developed by Cyberbotics corporation founded by the experts of Federal Polytechnic School of Lasagna (EFPL). It is the most functional robot simulation system operating in Windows, Mac OS and Linux systems.

This system supports robot simulation and its interaction with the physical environment, allows designing robot control programmes in C++, Java and Python programming languages. The system includes a lot of robot models. The information on the system including electronic textbook Cyberbotics' Robot Curriculum [7] is widely accessible.

Unfortunately, all programme versions including educational one are commercial. Free evaluation license provides programme only within a month, after which only editing of two standard models is accessible, the rest can be opened in playback mode without modification. Such limitations make application of this system in online courses impossible.

V-REP System

V-REP system [8] is a commercial version by Coppelia Robotics corporation, but its license makes possible to use it in education for free without functional limitations. V-REP system is accessible for Windows, Mac OS, and Linux.

In spite of the fact that interface operability and documentation somewhat yield to Webots system, V-REP can be efficiently used as a virtual robotic engineering laboratory.

V-Rep is a virtual modeling environment with integrated design sevice, which allows building different robotic engineering devices: from manipulator to robots floating in the plane or in water-air environment, as well as simulating their behavior simulation. The library has a great number of previously designed robots, behavior of all units and components that can be set by means of scripts.

The principle shortcoming in using V-REP in online school course is the need to know Lua programming language which is not taught at school. In fact, the system supports integration with 7 programming languages: C, Java, Python, Matlab, Octave, Lua and Urbi. However, the system core operates with Lua language, hence, to use other programming languages undoubtedly requires writing small adaptor programme in this language. Therefore, designing course of practical engineering modeling for pupils the authors took the decision to add a small section of Lua programming. This programming language is similar enough to other contemporary programming languages. It is hoped that its sufficient learning does not make a big difficulty for students having experience in other language programming. Otherwise, one has to use a code fragment unclear for students and refuse integrated design environment that makes system operation more complicated.

Conclusion on robotic engineering design systems

The combination of compatibility with all common operating systems and free educational license makes V-REP the only accessible system applicable for online courses as a virtual laboratory.

However, if the system is used in courses held in an education institution having special software, one can recommend using Webots system as an environment with large potential and usability.

ROS environment can be recommended for using in university educational programmes. Available open source codes allow application of this system in learning and developing algorithms of computer vision, inverse kinematics, localization, and mapping. ROS system is widely used in modern research. However, its application may cause problems related to system administration including installation of strictly fixed versions of operating systems.

Testing

In the frame of the state project of the RF Ministry of Science to arrange practice-oriented research-engineering clubs, the authors have developed the distance course for pupils “Bases of practical engineering modeling” using simulating systems considered in the article. The course takes 40 hours and considers issues related to design of built-in and robotic engineering systems.

The first part of the course is concerned with designing microprocessor-controlled electronic circuits using circuits.io virtual laboratory. The second part of the course based on V-REP system deals with high-level programming issues of robot behavior. In this case the attention is paid to such questions as navigation, territory survey, collision detection and response, interaction with the environment.

Conclusion

The article reviews contemporary virtual laboratories that can be used in engineering education, for instance, designing online courses, where one of the key challenges is a need for expensive laboratory equipment. The systems for modeling electronic circuits and robotic engineering have been considered. The performed analysis is based on practical use of virtual laboratories in the course developed by the authors “Bases of practical engineering modeling” for pupils. It is shown that use of virtual laboratories allows pupils to learn the issues of robotic engineering system design without special equipment.

REFERENCES

1. Shvetsov V.I., Sosnovsky S. Modernizatsiya prepodavaniya matematiki kak vazhneishei sostavlyayushchei mezhdistsiplinarnosti v inzhenernom obrazovanii. Инженерное образование. 2016. № 20. – P. 207-212.
2. Autodesk CIRCUITS [Electronic resource]. Accessed: https://circuits.io/
3. Ya prezirayu Arduino [Electronic resource]. Accessed: https://geektimes.ru/post/255760/
4. Robot Operating System [Electronic resource]. Accessed: http://www.ros.org
5. GAZEBO [Эл. ресурс]. Accessed: http://gazebosim.org
6. Webots [Electronic resource]. Accessed: http://www.cyberbotics.com/webots.php
7. Cyberbotics' Robot Curriculum [Electronic resource]. Accessed: https://en.wikibooks.org/wiki/Cyberbotics%27_Robot_Curriculum
8. V-REP. Virtual Robot Experimentation Platform [Electronic resource]. Accessed: http://www.coppeliarobotics.com

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Rewarding Learning of Maths in Engineering Schools: Laboratory Works

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The approach to development and use of laboratory works in training discrete mathematics and mathematical logic is suggested in the article. It is based on the computer tools to develop and improve productive thinking. The works involved are based on modeling subject field, they include target setting which determines students experimental and constructive activities as well as resources for automatical evaluation of partial solutions submitted by students. Experiment results have shown a significant increase in efficiency as compared to the multiple choice tests.

Key words: laboratory works, discrete mathematics, mathematical logic

Introduction

A laboratory work on discrete mathematics is often defined by most of contemporary authors as a set of problems on a definite subject aimed to develop students’ certain skills. It seems to us that under such an approach, performance of laboratory work is no different from solution of individual home task or a set of tests [1-3].

Traditional engineering education interprets laboratory work on mathematics as a training session being a basic unit of laboratory (calculating) practice, using numerical techniques to solve professional problems [4]. However, the solution of routine problems relevant to their future job is a relatively rare case, they are mostly “professional” engineering problems often called the applied problems.

Laboratory practice is to consist of examples of problem solutions modelled on the basis of creative individual tasks. In this case laboratory tasks intensify students’ independent work, contribute to better understanding of the subject and master their problem solution skills. In the classroom students take an active part in solution and analysis of the problems that they have to solve individually. Independent students’ solution of the problems promotes their better understanding of the theory and develops their practical skills of managing the tasks that relate to studying the discipline “Discrete mathematics”.

The training process will become more efficient if its participants solve non-trivial substantial problems and, for this purpose, they need to adopt new methods and tools including corresponding theory. Besides, the idea of learning process as a kind of research work increases the students’ motivation.

Hence, laboratory work on discrete mathematics is a basis for acquiring research competency of future engineers.

It should be noted that the terms “laboratory work” and “laboratory practice” are often used in the literature as synonyms. These terms are better to be distinguished. The basic difference of laboratory practice from a laboratory work consists in systematic nature of the former. The practice includes several laboratory works different in subject and, sufficiently isolated in time of performance, but united by common goal relative to a student’s specific training area.

To perform laboratory work of research type a number of scholars suggest active use of application packages (Maple, Mathematica, MatLAB etc.). Making solution of complex problems easier, they help students to overcome psychological barrier in learning mathematics and make the training process more interesting and less complicated. In this case students are able to solve of more complex problems compensating for the lack of their knowledge by using package capacity, learning to present the research results in the form of concise substantial reports.

As an example one can give the laboratory practice designed at P.G. Demidov Yaroslavl State University [5]. The practice was developed using Mathematical package and covers such parts of discrete mathematics course as "Theory of combinations", "Graph algorithms", "Boolean functions", "Alphabetic coding", and "k-valued functions".

It should be noted that there is a risk of turning computer laboratory work into calculation of some task using template, ignoring the research constituent. Computerization of calculation did not only solve this problem, but even worsen it shifting from the result analysis to the capacity of software [6].

Of significant interest is the trend to use Moodle virtual learning environment to introduce laboratory practices into learning process.

In [7] the authors have presented the review of laboratory practice developed at Moscow Institute of Physics and Technology. The laboratory practice was on the course "Fuzzy models of discrete mathematics" and integrated in the training process. Computerized practices provided visual support of the learning material, a variety of tasks, monitoring performed works, and detection of mistakes. The practice was developed on AdobeFlash platform. To introduce the practice into training, Moodle virtual learning environment is used to integrate the developed live content by means of the SCORM standard.

At present, to develop research problems on Graph Theory, Maple package is widely used to give good visualization, which is of no small importance for this course. The teaching materials on "Discrete mathematics" designed at National Research Moscow Power Engineering Institute based on the textbook may serve as a bright example [8]. The materials cover most of topics of graph theory included in the curriculum: search for minimal spanning tree, the shortest paths in graph, network saturation, coverings, colorings, Hungarian algorithm, Hamiltonian and Eulerian cycles, encoding trees, etc.

Let us give some more examples of successful cases of learning materials including laboratory works with research tasks.

In [9] the authors suggest a number of laboratory works on "Discrete mathematics" course intended for learning systems of computer mathematics and related software. For example, it includes study of Combination Theory section using Mathematica package, automaton modeling in Electronics Workbench environment and solution of fuzzy logic problems in Fuzzy Logic package of MathLab environment.

The workers of Siberian Federal University have developed a set of laboratory works [10] including a number of learning syllabuses on the Graph Theory. This set is also interesting by the fact that it has a build-up universal unit of computer testing Unitest developed by the university workers and intended for intermediate and final monitoring.

In Yaroslav-the-Wise Novgorod State University [11] a set of numerical problems has been suggested using the concept of logic programming. Of particular interest are the problems of human intellectual activity simulation in processing various types of information. The laboratory works also allow acquiring skills of writing and checkout of programmes in Prolog language to build up intellectual systems for different purposes.

As a conclusion of reviewing the computerized laboratory complexes the latest development by Vyatka State University [12] should be considered. A set of emulators is suggested to study complicated sections of discrete mathematics. The emulators show the methods of solving such problems as: set operations, power of cluster sets, network and graph problem solutions, etc.

In addition to "computerized" laboratory works, mention should be made that the themes of course papers on discrete mathematics suggested by different authors [13] can also be used as creative laboratory tasks. Such course papers of small volume can be employed as topics for several laboratory works on corresponding theme.

In works [14-19] there is an approach to learning mathematics based on interaction with subject models of the concepts and evaluation of partial definition of those notions. This approach makes possible for students to have computer support of their cognitive activity. It is also interesting to consider using integration of two different interpretations of studied concepts. In this case when writing a problem a problem description is used as a set of its solution conditions, whereas in the process of solution – another, for example, algorithmic description of solution is used [20, 21].

Psychological and methodological bases of using computer tools in education

The approach to laboratory works on discrete mathematics, mathematical logics, and algorithm theory described in the article is based on computer tools to support productive thinking [22, 23].

The approach is based on Wertheimer's works, where a concept of productive thinking was first introduced [24], Vygotsky's research on the role of tools in human mind development [25], Leontiev's works on mechanism of interiorization [26] and those by Yakimanskaya concerned with using this mechanism to form significant mathematical notions [27], Krylov's research on methodical aspects of engineering education [28], Kudryavtsev's works on the structure of engineering thinking [29], Papert's study dealing with the role of tools in the formation of mathematical concepts [30], Polya's works on research approach in studying mathematics [31, 32], research on the theory of IT environment [22] and information space [33].

Wertheimer [24] has shown that development of mathematical concepts is possible only with the support on basic concepts which are used by the students. Another related effect is understanding, which is a student's subjective feeling.

Use of analogues and models is connected with applied focus of teaching that is well formulated by academician A. N. Krylov [28]: "...any engineer should be a practioner, technician, ... is to develop not only his mind, but also his feelings so that they would not deceive him, he has not only to be able to look, but also see ... has to reduce his considerations not to Descartes' humble conclusion "I think, therefore, I am", but to a firm practical idea "I see, hear, touch, feel, therefore, it is so".

Kudryavtsev [29] has introduced a concept of engineering thinking. The main feature of engineering knowledge is that it is conceptual – visual – actual knowledge. In other words, dealing with a definite object it is necessary to have its structural image in the mind and perform some specific actions depending on this structure.

Modeling mathematical concepts and using computer models to teach mathematical logics and algorithm theory

As mentioned above, one of the ways to form a comcept in a student's mind is to put the concept outside, substantiate it, make possible to handle it as an external object.

The challenge consists in the fact that, initially, the intellect structure of any student is unknown, so, the means to perform individual training are still absent. Therefore, an important task is to reveal and use common methods that initiate each student's activity in acquiring new ideas. It requires revising the basic concepts and using information environment to model something that will turn into every student's internal intellectual structure in the process of interiorization.

For this purpose, materialized simulated model should be simple enough, thus, to provide its flexibility and allow every student to use his/her own internal interpretation – *model should give intellectual freedom to students* [19]. By no means, it cannot be based on rigid teaching methods that make students, directly or indirectly, adjust to it. Vice versa, working with the model, a student projects it to his/her intuitive ideas that can contradict substantial aspects of a concept securely fixed by the model, and create a problem-based situation leading to new knowledge formation

Let us enumerate the basic properties of the models underlying laboratory models: the first is *flexibility of interpretation*, the second is *setup stiffness of substantial properties.* It should be also noted that the objects with these properties are called "boundary objects" in the theory of information environment [33], by means of which communities exchange information via information space.

Laboratory work will mean a set of the following elements:

- model of subject area related to the concept under study;
- target setting defining students' experimental-constructive activity;
- tools of automatic evaluation of partial solutions submitted by students.

At first glance, it seems that if we have a formal definition of a concept, the model of subject area is built automatically. However, it is far from being so, as user interface is of great significance, which has to limit student actions to the extent that it should provide freedom in generating different solutions, but in a strictly limited area.

Let us give an example of a model. The problems of building finite-state automation are placed in the environment for graph constructing of finite-state machine. One of the methodical problems that should be solved in designing interface is to use a model of non-deterministic or deterministic machine. The choice of deterministic machine was defined by the problem essence. However, one can use the model of non-deterministic machine and check a determinacy as a part of problem. It is these solutions that should be performed by an educator in terms of freedom degree given to a student [19]. As mentioned above, it should be sufficient to implement his/her own ideas and not to direct the students' activity towards the predetermined solution. On the other hand, if a model has too many free parameters, a student has a possibility to experiment with parameters that the educator has connected with another problem. Hence, in the given example the model does not allow a student to build non-deterministic machine. It can be considered as a feedback contributing to better students' understanding of a set problem.

The limitation of model operating environment is not the only way to obtain the feedback. The key element of feedback is the possibility to check the experimentally-based solutions using examples.

For example, a designed identification machine can be verified by different input symbol string. It makes possible to react to a particular solution. To check the final solution, the algorithm of equivalency checking is used.

Thus, we are able to formulate the idea: *when developing supporting software of learning mathematics it is necessary to transfer pedagogical techniques, the most appropriate for the set targets, to the new environment. The goal of this transfer is to automate monitoring of students' productive activity providing them with cognitive freedom consistent with the pedagogical task.*

Experiment and Initial Results

Based on the presented approach four laboratory works were developed, each of which included four problems of various complexities. The themes of works were "Logic circuits", "Finite-state automation and regular expressions", "Predicates and quantifiers (Tarski's world)", "Turing machine". 3 student classes participated in the experiment – 20 student groups, about 300 students. The experiment outcomes were estimated in three ways: examination results, teacher evaluation, and students' questionnaire.

The number of problems solved correctly at a written test grew by 20%, whereas the mistakes in problem solution of laboratory works were twice as little as compared to solving the problems without the support of laboratory work. Based on the students' answers, it can be concluded that the effect of laboratory work on mastering the concepts is sufficiently higher than the effect of traditional multiple choice tests that was performed simultaneously with laboratory works.

REFERENCES

1. Gavrilov G.P., Sapozhenko A.A. Zadachi i uprazhneniya po diskretnoi matematike [Problems and exercises on discrete mathematics]. Moscow: Fizmatlit, 2005. – 416 p.
2. Lavrov I.A., Maksimova L.L. Zadachi po teorii mnozhestv, matematicheskoi logike i teorii algoritmov [Problems on set theory, mathematical logics and algorithm theory]. Moscow: Fizmatlit, 2004. – 256 p.
3. Likhtarnikov L.M., Sukacheva T.G. Matematicheskaya logika: kurs lektsii. Zadachnik-praktikum i resheniya [Mathematical logics]. Saint-Petersburg. [et al]: Lan', 2008. – 288 p.
4. Pionova R.S. Pedagogika vysshei shkoly: uchebnoye posobie [Pedagogy of higher school]. Minsk: Universitetskoye Publ, 2002. – 256 p.
5. Bashkin M.A., Durnev B.G. Innovatsionnye metody v prepodavanii distsipliny «Diskretnaya matematika» [Innovative methods in teaching discipline "Discrete mathematics"]. Mezhdunarodnyi zhurnal eksperimental'nogo obrazovaniya [International journal of experimental education]. 2010. № 9. – pp. 97–98.
6. Ryndina Yu.V. Formirovanie issledovatel'skoi kompetentnosti studentov v ramkakh auditornykh zanyatii [Development of student research competence at the classes]. Molodoi uchenyi [Young scientist]. 2011. V. 4, № 2. – pp. 127–131.
7. Tikhomirova A.N., Nesilovskaya E.A., Kulinichev E.A., Khat'ko E.E. Razrabotka laboratornogo praktikuma po kursu «Nechetkie modeli diskretnoi matematiki [Development of laboratory practice on Fuzzy models of discrete mathematics] [Electronic resource] Sovremennye problemy nauki i obrazovaniya [Modern problems of science and education]. 2012. No. 3. Available at: https://www.science-education.ru/ru/article/view?id=6439, (Accessed: 16.03.2017) (in Russ).
8. Kirsanov M.N. Grafy v Maple [Graphs in Maple]. Moscow: Fizmatlit, 2007. – 168 p.
9. Alyaev Yu. A., Tyurin S. F. Diskretnaya matematika. Prakticheskaya diskretnaya matematika i matematicheskaya logika [Discrete mathematics. Practical discrete mathematics and mathematical logics]. Moscow: Finansy i Statistika, 2012. – 384 p.
10. Bogul'skaya N.A., Postnikov A.I., Isayev S.V. Diskretnaya matematika : ucheb. posobie po tsiklu lab. zanyatii [Discrete mathematics]. Krasnoyarsk: Publ. SFU, 2008. – 147 p.
11. Mikhailov D.V., Yemelianov G.M. Funktsional'noe i logicheskoe programmirovanie: lab. Praktikum [Functional and logical programming]. Veliky Novgorod: Publ. NovSU Yaroslava Mudrogo, 2007. Part 2. – 88 p.
12. Knyaz'kova T.V. Programmnyi obuchayushchii kompleks po discrete mathematics dlya distantsionnogo obucheniya [Programmed learning complex on discrete mathematics for distance learning]. Sbornik tezisov dokladov na 14 otkrytoi vserossiysloy konferentsii "Prepodavanie informatsionnykh tekhnologii v Rossiiskoi Federatsii" (g. Sain-Petersburg, 19–20 maya 2016 g.) [Proceedings of the 14-th Open All-Russian Conference]. Moscow: 1C-Publishing, 2016. – pp. 204–206.
13. Molchanov V.A., Novikov V.E., Otryvankina T.M., Pronin P.N., Firstov V.E.. Sbornik tem kursovykh rabot po matematike (algebra, matematicheskaya logica, diskretnaya matematika [Collection of themes for course papers on mathematics (algebra, mathematical logics, discrete mathematics)]. Orenburg: Publ. Orenburg State University, 2004. – 68 p.
14. Rybin S.V. Sistema podderzhki distantsionnogo obucheniya s ispol'zovaniem internet-tekhnologii[SystemofdistancelearningsupportusingInternet-technologies].Komp'yuternye instrumenty v obrazovanii [Computer tools in education]. 2007. № 5. – pp. 49–54.
15. Ivanov S. G. Rabota na urokakh matematiki so sredoi Verifier [The work with Verifier environment at math lessons]. Komp'yuternye instrumenty v obrazovanii [Computer tools in education]. 1998. № 1. – pp. 58–66.
16. Mantserov D.I. Sreda Verifier-KD: verifikatsiya reshenii zadach po matematike [Verifier-KD environment: verification of problem solutions on mathematics]. Komp'yuternye instrumenty v obrazovanii [Computer tools in education]. 2006. № 4. – pp. 36–41.
17. Pozdniakov S., Posov I. Domain specific language approach to technology-enhanced learning. RJMT. 2014. Vol. 3, № 1 (June). – pp. 106–116.
18. Bogdanov M., Pozdnyakov S., Pukhov A. Multiplicity of the knowledge representation forms as a base of using a computer for the studying of the discrete mathematics. Pedagogika. 2009. Vol. 96. – pp. 136–142.
19. Ivanov S.G., Mamayeva S., Pozdniakov S.N., Stepulenok D.O., Entina S.B. Computer support for distant learning research on mathematics. Komp'yuternye instrumenty v obrazovanii [Computer tools in education]. 2004. № 2. – pp. 5–18.
20. Bogdanov M.S. Avtomatizatsiya proverki resheniya zadach po formal'nomu opisaniyu ee usloviya [Automated checking the problem solutions according to formal description of their conditions]. Komp'yuternye instrumenty v obrazovanii [Computer tools in education]. 2006. № 4. – pp. 51–57.
21. Perchenok O.V., Pozdniakov S.N., Posov I.A. Avtomatizatsiya proverki resheniya geometricheskikh zadach po opisaniyu ikh uslovii na predmetno-orientirovannom yazyke [Automated checking the geometrical problem solutions according to description of their conditions in subject-oriented language]. Komp'yuternye instrumenty v obrazovanii [Computer tools in education]. 2012. № 1. – pp. 37–44.
22. Bashmakov M.I., Pozdniakov S.N., Reznik N.A. Informatsionnaya sreda obucheniya [Information learning environment]. Saint-Petersburg: Svet, 1997. – 121 p.
23. Teoriya i praktika produktivnogo obucheniya [Theory and practice of productive learning]. Bashmakov M.I. (eds.). Moscow: Narodnoye obrazovaniye, 2000. – 284 p.
24. Wertheimer M. Produktivnoe myshlenie [Productive thinking]. Moscow: Progress, 1987. – 302 p.
25. Vygotsky L.S. Myshlenie i rech' [Thought and speech]. Moscow: Labirint, 1999. – 352 p.
26. Leontiev A.N. Deyatel'nost'. Soznanie. Lichnost' [Activity. Conscious. Personality]. Moscow: Politizdat, 1975. – 304 p.
27. Yakimanskaya I.S. Razrabotka tekhnologii lichnostno-orientirovannogo obucheniya [Development of techniques for student-oriented teaching]. Voprosy psikhologii [Questions of psychology]. 1995. № 2. – pp. 31–42.
28. Krylov A.N., Yakimanskaya I.S. Znachenie matematiki dlya korablestroitelya [Significance of mathematics for a ship-builder]. Vospominaniya i ocherki [Memoirs and essays]. Moscow: Publ. ANSSSR, 1956. – 884 p.
29. Kudryavtsev T.V., Yakimanskaya I.S. Razvitie tekhnicheskogo myshleniya uchashchikhsya [Development of students' creative thinking]. Moscow: Vysshaya Shkola, 1964. – 88 p.
30. Papert S. Perevorot v soznanii: deti, komp'yutery i plodotvornye idei: per. s angl [Paradigm shift: children, computers, and fruitful ideas]. Moscow: Pedagogika, 1989. – 222 p.
31. Polya D. Kak reshat' zadachu : posobie dlya uchitelei [How to solve a problem]. Tr. from English by V.G. Zvonareva, D.N. Bell; Yu. M. Gaiduk (eds.). 2-nd edition. Moscow: GIZ MP RSFSR, 1961. – 208 p.
32. Polya D. Matematicheskoe otkrytie. Reshenie zadach: osnovnye ponyatiya, izuchenie i prepodavanie [Mathematical discovery. Problem solution: main concepts, learning, and teaching]. Tr. from English. Moscow: Nauka, 1970. – 452 p.
33. Bannon Liam J. Constructing common information spaces / Liam J. Bannon, Susanne Bodker. ECSCW'97: Proc. Fifth Europ. Conf. on Computer Supported Cooperative Work, Lancaster, UK, 7–11 Sept. 1997. Dordrecht [etc.]: Kluwer Acad. Publishers, 1997. – pp. 81–96.


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UDC 378

Designing ICT Education Programmes Based on Professional Standards

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The article describes experience of the Russian universities in designing education programmes in the field of information and communication technologies based on professional standards.

Key words: competence approach, engineering education, professional standards, federal state educational standards.

Introduction

In 2011, the third-generation federal state educational standards were implemented in Russia. One of the key particularities of these new standards is competency approach to education, which means that the emphasis has shifted from education content towards learning outcomes clear for all interested stakeholders – employers, teachers, students. Learning outcomes are described in the form of competencies comprising knowledge, abilities, and skills, professional experience and personal qualities, which the graduate should develop and obtain.

At present, Russian universities should develop education programmes, which meet the professional standards, and an adequate assessment system. In this regard, the experience of leading Russian university can be rewarding: implementing the international project METAMATH "Modern Educational Technologies for Math Curricula in Engineering Education of Russia" and the national scientific and methodological projects "Scientific and Methodological Support for Developing Exemplary Principle Professional Education Programmes (EPPEP) for Different Profiles", "Models for Harmonizing Professional Standards and Federal State Educational Standards of Higher Professional Education (FSES HPE) in Mathematics, Natural Sciences, Farming Sector and Agricultural Sciences, Social Sciences, Humanities (Specialist's, Bachelor's, and Master's Degree)" [1, 2]. The present paper describes the experience in the sphere of Information and Communication Technologies (ICT) education.

Competency approach in education

The level of mathematical knowledge is an essential aspect of successful engineering and natural sciences education, since mathematics is the key subject in engineering. If the second-generation standards prescribed the disciplines to be learned and described the content, the third-generation educational standards are a kind of framework. Every university is to select the disciplines to be taught and define the number of credits, which does not always ensure profound mathematical and engineering education [3]. Some careless duty-holders thus get an opportunity to reduce the number of hours for mathematical disciplines taught within ICT engineering profile and lower other parties' sights. Today, universities should be very careful in selecting the content of mathematical disciplines and take into account future professional activities and tasks [4].

When designing and implementing education programmes, one should stick to competency approach, which aims at developing general, professional, and personal competencies of higher engineering school graduates. The competency approach implies:

- listing competencies essential for Specialist's, Bachelor's, and Master's degree;
- designing engineering education programmes based on professional standards.

An attempt to resolve these tasks was made within the scope of the project "Scientific and Methodological Support for Developing Exemplary Principle Professional Education Programmes (EPPEP) for Different Profiles". The project stakeholders designed the exemplary principle education programmes aimed at developing general and professional competencies within consolidated profiles (UGSN). Professional competencies for Bachelor's and Master's degree, UGSN 02.00.00 being revised, they suggested an updated list of competencies with due regard to particular profiles and mathematical education [5].

According to the methodological recommendations passed by the Ministry of Education and Science of the RF dated 22.01.2015, when designing principle education programmes, universities and institutes should take into account the relevant requirements of the professional standards. The professional standard is description of qualification which a graduates need to perform this or that professional activities. The foundation of educational standards should rest on professional competencies focused on employment functions (professional activities), which are prescribed by the professional standards.

Brining the sections of FSES HPE into compliance with professional standards

One of the ways to enhance education programmes and bring them into compliance with the professional standards was suggested within the project "Scientific and Methodological Support for Developing Exemplary Principle Professional Education Programmes (EPPEP) for Different Profiles". The project stakeholders designed the exemplary principle education programmes aimed at developing general and professional competencies within consolidated profiles (UGSN) [6, 7].

We analyzed the content and structure of the professional standards and came to the conclusion that there is no unambiguous correlation found between professional spheres and educational profiles. Therefore, in FSES 3+ we have identified the "core" cultural and professional competences, which are independent of particular professional activities and programme profile. The "core" is the major part of the education programme, it is fundamental and unchangeable. The "optional" part should be focused on specific employment functions or professional activities, prescribed by the professional standards (if there are any). This part should be renewable and easily updated to cater the demands of labour market.

[6, 7] describe the exemplary principle education programme for Bachelor's and Master's degrees "Mathematical and Natural Sciences" developed by the project stakeholders within UGNS 02.00.00 "Computer and Information Science". This programme comprises 6 profiles (both Bachelor's and Master's degrees):

- Mathematics and Computer Science.
- Fundamentals of IT and Information Technologies.
- Information Systems Software and Administration.

We analyzed if the enhanced general professional competencies (OOPK) comply with generalized employment functions (GEF) and employment functions (EF) connected with professional activities of Bachelor's and Master's degree programmes' graduates.

To design the exemplary education programme "Mathematical and Natural Sciences" within UGNS 02.00.00 "Computer and Information Science", we selected the professional standards and generalized employment functions (GEF) connected with professional activities of programme's graduates. The criteria were as follows:

- type of professional activity described in professional standards;
- level of qualification described in professional standards and correlated with the academic degree;

- requirements of employers whom the programme designers cooperate with.

Many IT professional standards contain GEFs implying software design:

- POU integration and software testing;
- requirements engineering and software design (professional standard "Programmer");
- design of software architecture options;
- selection and assessment of a software architecture option;
- software implementation (professional standard "Software Architect");
- component-based software engineering (professional standard "System programmer").

As a result, one of the suggested GPCs for Bachelor's degree has been formulated as OOPK-II (B_02) – an ability to design, analyze, and implement algorithms to resolve professional tasks.

Based on GEFs comprising EFs and their components (knowledge, skills, and professional activities) one can split competency development into learning stages and identify relevant learning outcomes. As an example, let us consider OOPK-II map tile (tabl. 1).

It is clear that education programmes should be provided with testing and assessment tools, which enables evaluating the level of the competency development [8-12]. Therefore, development of efficient testing and assessment tools is another challenge for teaching community [13].

Besides general professional competencies, the educational standards include professional competencies (PC) focusing on a particular type of activity. The idea of professional competency design is approximately the same as that of general professional competency, but the professional competency includes a smaller number of employment functions. For instance, the employment function "determining probable types of every component" in the professional standard "Software Architect" corresponds with the research activity, while the employment functions:

- designing database back-up procedures,
- designing of database recovery procedures
- in the professional standard "Database Administrator" correspond with project, production and engineering activities.

Table.1. Enhanced general professional competency OOPK-II: map tile

Stage (level) of competency development	Expected learning outcomes (indicators of relevant level)
First stage (level) Ability to implement basic algorithms into software	Z (OOPK-II) –1: to know programming languages
	Z (OOPK-II) –1: to know basic algorithms of information processing
	U (OOPK-II) –1: to be able to use programming languages to implement algorithms
	V (OOPK-II) –1: to be able to use software for design
Second stage (level) Ability to design and analyze software to resolve various tasks	U (OOPK-II) – 2: to be able to design software packages
	V (OOPK-II) – 2: to be able to analyze software
Third stage (level) Ability to design new algorithms and measure their efficiency	Z (OOPK-II) – 3: to know common measures of algorithm efficiency
	V (OOPK-II) – 3: to be able to design and enhance algorithms
	V (OOPK-II) – 3: to be able to determine the level of complexity and measure algorithm efficiency

Conclusion

In this paper, we have described the principle of competency design for IT graduates, which is based on the professional standards.

REFERENCES

1. Zakharova I.V., Kuzenkov O.A., Soldatenko I.S. Proekt MetaMath programmy Tempus: primenenie sovremennykh obrazovatel'nykh tekhnologii dlya sovershenstvovaniya matematicheskogo obrazovaniya v ramkakh inzhenernykh napravlenii v rossiiskikh universitetakh [MetaMath (Tempus project)]: up-to-date educational technologies to improve mathematical education for engineering students of Russian universities]. Sovremennye informatsionnye tekhnologii i IT-obrazovanie [Modern Information Technologies and IT-Education], 2014, no. 10. – pp. 159–171. (In Russ.).
2. Kuzenkov O.A., Ryabova E.A., Biryukov R.S., Kuzenkova G.V. Modernizatsiya programme matematicheskikh distsiplin NNGU im. N.I. Lobachevskogo v ramkakh proekta MetaMath [Modernisation of programmes of mathematical disciplines of NNGU within the MetaMath project]. Nizhegorodskoe obrazovanie [Education in Nizhny Novgorod], 2016, no. 1. – pp. 4–11. (In Russ., abstr. in Engl.).
3. Zakharova I.V., Syromyasov A.O. Otechestvennye standarty vysshego obrazovaniya: evolyutsiya matematicheskogo soderzhaniya i sravnenie s finskimi analogami [Native standards of higher education: the evolution of the mathematical content and comparison with the Finnish algirithms]. Vestnik Tverskogo gosudarstvennogo universiteta. Seriya: Pedagogika i psikhologiya [Bulletin of Tver State University. Pedagogy and Psychology], 2016, no. 2. – pp. 170–185. (In Russ., abstr. in Engl.).

4. Zakharova I.V., Yazenin A.V. O nekotorykh tendentsiyakh sovremennogo matematicheskogo obrazovaniya na primere analiza GOS VPO, FGOS VPO i FGOS VO po napravleniyu podgotovki "Prikladnaya matematika i informatika" [Current trends in mathematical education: case-study of GOS VPO, FGOS VPO, and FGOS VO for "Applied Mathematics and IT" profile]. Obrazovatel'nye tekhnologii i obshchestvo [Educational Technology & Society], 2015, vol. 18, no. 4. – pp. 629–640. (In Russ.).
5. Zakharova I.V., Dudakov S.M., Yazenin A.V., Soldatenko I.S. O metodicheskikh aspektakh razrabotki primernykh obrazovatel'nykh programme vysshego obrazovaniya [Developing exemplary higher education programmes: methodological aspects]. Obrazovatel'nye tekhnologii i obshchestvo [Educational Technology & Society], 2015, vol. 18, no. 3. – pp. 330-354. (In Russ.).
6. Zakharova I.V., Dudakov S.M., Yazenin A.V. O razrabotke magisterskoi programmy po UGNS "Komp'yuternye i informatsionnye nauki" v sootvetstvii s professional'nymi standartami [On the development of curriculum on UGNS "Computer and Information Science" in accordance with professional standards]. Vestnik Tverskogo gosudarstvennogo universiteta. Seriya: Pedagogika i psikhologiya [Bulletin of Tver State University. Pedagogy and Psychology], 2016, no. 2. – pp. 84–100. (In Russ., abstr. in Engl.).
7. Zakharova I.V., Dudakov S.M., Yazenin A.V. O razrabotke magisterskoi programmy po UGNS "Komp'yuternye i informatsionnye nauki" v sootvetstvii s professional'nymi standartami [On the development of Master's programme on UGNS "Computer and Information Science" in accordance with professional standards]. Vestnik Tverskogo gosudarstvennogo universiteta. Seriya: Pedagogika i psikhologiya [Bulletin of Tver State University. Pedagogy and Psychology], 2016, no. 3. – pp. 114–126. (In Russ., abstr. in Engl.).
8. Kuzenkov O.A., Kuzenkova G.V. Biryukov R.S. Razrabotka fonda otsenochnykh sredstv s ispol'zovaniem paketa Mathbridge [Mathbridge software for assessment tools development]. Obrazovatel'nye tekhnologii i obshchestvo [Educational Technology & Society], 2016, vol. 19, no. 5. – pp. 465-478. (In Russ.).
9. Novikova S.V. Preimushchestva komp'yuternykh trenazherov pri izuchenii vychislitel'nykh metodov [Advantages of computer simulators in learning computational methods]. Obrazovatel'nye tekhnologii i obshchestvo [Educational Technology & Society], 2015, vol. 18, no. 2. – pp. 478–488. (In Russ.).
10. Novikova S.V. Problemy integratsii praktiko-laboratornykh modulei v distantsionnyi obuchayushchii kompleks sredy Learning Space [Distance learning in Learning Space: challenges of lab modules integration]. Obrazovatel'nye tekhnologii i obshchestvo [Educational Technology & Society], 2014, vol. 17, no. 4. – pp. 543–553. (In Russ.).
11. Novikova S.V., Valitova N.L., Kremleva E.Sh. Osobennosti sozdaniya uchebnykh ob"ektov v intellektual'noi sisteme obucheniya matematike Math-Bridge [Designing learning objects on e-learning platform Math-Bridge]. Obrazovatel'nye tekhnologii i obshchestvo [Educational Technology & Society], 2016, vol. 19, no. 3. – pp. 451–462. (In Russ.)
12. Zakharova I.V., Kuzenkov O.A. Opyt realizatsii trebovanii obrazovatel'nykh i professional'nykh standartov v oblasti IKT v Rossiiskom obrazovanii [Educational and professional standards for ICT education: experience of implementation]. Sovremennye informatsionnye tekhnologii i IT-obrazovanie [Modern Information Technologies and IT-Education], 2016, vol. 12, no. 1–3. – pp. 17–31. (In Russ.).

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Towards the Issue of Quality of Engineering Education

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The article considers issues related to the quality assurance of higher engineering education, examines the global experience in this regard and ways to deal with the challenges. It is shown that one of the principal mechanisms to ensure and assess the quality of education is a professional and public accreditation (PPA) of education programmes (EP). The purposes and objectives of the professional and public accreditation, benefits for graduates of accredited programmes in the career development of a professional engineer are described. The practice and outcomes of the activities of the Association for Engineering Education of Russia (AEER) in the accreditation of education programmes in the field of engineering and technology are presented.

Key words: educational trends, professional and public accreditation, university rankings.

Introduction

One of the basic factors of sustainable economic development is significant improvements in staffing the enterprises that are involved in developing and implementing the breakthrough technologies. It is impossible to resolve this task without strengthening the entire system of higher professional education. Therefore, a new approach aimed at solving the most serious problems faced by the mankind in the XXI century is being implemented. The priorities of the sustainable socio-economic development of the society are as follows: improvement of citizens' life quality, economic growth, science, technologies, education, health and culture, ecology and environmental management [1]. A new paradigm of engineering education appears. Its main feature is that education has shifted the focus from knowledge transmission to practice-oriented lifelong education that rests on the fundamental theories. In view of the above, Russian high school is currently facing the task to assure high quality of Russian education and succeed on the global educational market.

Trend and tasks of Higher Professional Education

The following trends can by identified in Russian and foreign systems of higher professional education:

- The breaking down of the national borders: the increase in student and faculty staff mobility, development of international partnerships, participation of the international experts in thesis defense, the growth in import and export of education services and research, emergence of global players on the Russian education market and the risk of "education sovereignty" loss. The only way to survive for the higher professional education is to train graduates for a special niche or sector of economy, i.e. to take on the role of "an agent" of region/sector development.
- Orientation of universities towards the demands of the society and economy: whole scale long-life learning, devaluation of traditional diplomas, emergence of new assessment bodies (independent certification agencies, standards of leading companies (Microsoft certification)), gradual privatization of higher education by business, building of new-type campuses (educational

transfer centers), focus on team-building and spreading of project universities.

- Changes in educational and scientific content: individual "unattended" education (educational fast-food) based on new approaches (individual study paths, all day long learning – 24/7, simulators and virtual education).
- Changes in the scientific research procedure: projects aimed at preserving scientific schools, self-assembly research teams, development of interdisciplinary research, dissemination of research outcomes (including those in public press), the growing number of scientific inventions for industries, research on the basis of virtual laboratories and cloud technologies.
- Development of new patterns to coordinate society: new approaches to evaluating university and its graduates' performance, student scientific society as a platform for introducing new teaching tools, integration of student and professional associations, education aimed at training teams capable of handling various tasks (the key competency of an educator – ability to make up creative teams for solving various problems).

In line with the above, in order to enhance competitiveness of the country in the context of globalization, the Russian high school should tackle the strategic task – to ensure high quality of Russian education and its recognition on the global market. The latter is impossible to reach without introducing effective quality management systems. In this regard, the tools to evaluate the level of graduates' training are becoming especially important.

The quality of education is ensured by well-designed education programmes, qualitative teaching technologies and resources (including financial ones), the level of interaction with the strategic partners, efficiency of the implemented quality management system, and graduates' training quality. Hence, the education quality assurance patterns developed by universities should correspond to informational resources and facilities, staff, and certain requirements imposed by the society, personality, and the state.

Analyzing global experience in evaluating university performance, three basic approaches have been identified: reputational, result-oriented, and total. The reputational approach involves experts to evaluate the quality of educational programmes and universities. Result-oriented approach is aimed at evaluating quantitative values of university performance. The total approach rests on the principles of the Total Quality Management, TQM and requirements for the Quality Management Systems imposed by International Organization for Standardization, ISO. The other approaches are, to various extent, a combination of the described methods.

Professional and public accreditation of education programmes: goals and objectives

Let us take a closer look at the reputational approach. Being one of the most widely applied in educational community, this approach is primarily based on the procedure of accreditation of training process, in general, and education programmes, in particular.

Accreditation is a system of education quality assessment which allows considering the interests of all stakeholders. It combines both public and state forms of monitoring.

The main goals of accreditation are as follows:

- to ensure advance in higher education quality;
- to ensure efficient evaluation of educational service quality, in general, and education programmes, in particular;
- to foster development of educational establishments and enhancement of education programmes via continuous self-examination and planning;
- to guarantee the society that the educational establishment or a certain education programme has adequate learning outcomes and the ways to achieve them;
- to support in developing and enhancing educational establishments and implemented education programmes;
- to protect educational establishments from the interference into the teaching process and infringement of academic freedom.

In higher education, there are various types of both state (performed by the authorized governmental bodies) and public accreditation. It is worth noting that professional and public accreditation is increasingly popular in evaluating quality of education programmes offered by universities. This type of accreditation is of particular interest. It is proved by the fact that within the framework of the Bologna Declaration the development of professional and public (non-state) accreditation is one of the key issues [2].

Professional and public accreditation of education programmes is basically defined as a procedure aimed at evaluating the quality of a university performance in implementing certain education pogrammes. It is designed to define a university status to show the public that university has met and is maintaining high level of standards set by professional communities (associations), experts-volunteers, specialists, representatives of various industries (employers) and peer universities [3]. As a rule, a certain education programme undergoes accreditation.

Thus, professional and public accreditation of education programmes is a non-governmental system of education programme quality assessment and incredibly important facet of high-quality specialists' training. Such accreditation is considered an effective tool to assure all stakeholders of an education programme (school leavers and their parents, students, employers, authorities, the public in general) that it meets high standards of educational quality, i.e. is in line with their requirements and expectations.

Accreditation of education programmes allows universities timely respond to the changes in business and labor market and foster development and enhancement of training process in accordance with the requirements of the public via the system of quality assessment criteria.

Precisely, the network interaction model between universities and enterprises has been actively introduced into the training process over the past years. The network interaction, being a flexible form of integration processes that may occur in education system, provides much wider access to the most up-to-date learning tools and technologies, allows piloting new forms of teaching and content including e-learning and distance education [4]. Additionally, the network interaction model inevitably leads to facilitating indirect contacts: on the one hand, the number of contacts and interactions is increasing, therefore, the results are becoming more qualitative and efficient [5]. On the other hand, the question arises: what are the criteria to evaluate the efficiency of this model? What is the way to assess the quality of specialists' training within a certain discipline and the entre education programme provided electronically? Many scholars and faculty members pose these questions, which, definitely, should be reflected in the criteria of education programme quality assessment.

Attending an accredited programme in the field of engineering and technology can mean for a graduate the first step into the corresponding professional community with a further possibility to obtain appropriate professional licensure in the field and apply for the international professional registration:

- International Professional Engineers Register.
- APEC Engineer Register.
- International Engineering Technologists Register.
- International Engineering Technicians Register.

In Russia, the system of professional certification of engineers is only beginning to take root. In western countries, the certificate of the international professional registration is absolutely essential for career growth both in the industrial and academic sectors. Additionally, being recognized as a specialist in a certain field, an employee can count on additional bonuses (social and educational, insurance). Such specialists are in great demand, as highly-qualified and skilled engineers significantly influence the company performance, i.e. winning various contracts (contracts on supply of the equipment, technology development, etc.).

Obtaining an accredited degree is absolutely beneficial for students, as well. In some countries, students who attend an accredited programme are the only one who eligible for federal financial aid. These facts prove the validity and market weight of the accredited programmes [3].

In the course of professional and public accreditation, universities are given the recommendations on improving their education programmes. The recommendations are given by the experts who have gained vast experience in evaluating various educational esta-blishments and obtained deep knowledge in education quality assurance [3]. This enables universities to enhance their competetivness, thus, the competitiveness of their graduates both on the national and international markets of intellectual labor.

Another important objective of any national professional and public accreditation is to maintain recognition of the programme quality at the international level. To achieve this objective, it is required to harmonize national accreditation policy with the similar foreign ones including international associations and agencies in the corresponding field.

All the above-mentioned factors significantly help professional and public accreditation contribute to assuring high standards of education quality.

AEER Accreditation

One of the main activities of Association of Engineering Education of Russia (the Association, AEER) is professional and public accreditation of engineering programmes. The Association has developed and advanced the professional and public accreditation of education programmes since 2002 [6]. According to the Federal Law "About Education in the Russian Federation", AEER is entrusted to conduct professional and public accreditation of various education programmes in the field of engineer¬ing and technology. In compliance with this law, such accreditation demonstrates to the public that students graduated from an accredited university are properly educated according to the standards of educational quality agreed upon by professional experts, labor market specialists, and representatives of the corresponding industrial sector [7].

Compliance with the AEER criteria would guarantee the quality and continuous advancement of education programmes offered by universities. AEER accreditation criteria and procedure have been developed with regard to the Bologna Declaration for bachelor's, specialist's and master's degree programmes (the first and the second cycles) [7]. When developing the accreditation criteria, the association considers the world's best practices in engineering education quality assessment. The programmes accredited by AEER are registered in the Association, ENAEE (European Network for Accreditation of Engineering Education), submitted to the Federal Education and Science Supervision Service, covered by the mass media and appeared on the sites of AEER and ENAEE.

The criteria are set for learning outcomes evaluation. The learning outcomes imply a combination of competencies, knowledge, skills, abilities, methodological culture acquired by students upon completion of the education programme. They are designed in line with the requirements set for graduates by the professional community. An education programme can be accredited only if it meets all the above-mentioned criteria.

It an educational programme is suc-cessfully accredited, both bachelor's and master's degree programmes are signed 2 cer-tificates (AEER certificate and the EUR-ACE Label certificate). Specialist's degree prog-rammes may be awarded 3 certificates: AEER certificate, the EUR-ACE Label certificate, and the Washington Accord certificate.

AEER is the only association in the Russian Federation, which is entrusted to award education programmes a common quality label "EUR-ACE label" (bachelor's degree, master's degree), as well as to sign certificates of compliance to the requirement of the Washington Accord (Specialist's degree). The above-mentioned certificates are regarded as international ones and are recognized in the signatory countries of ENAEE and the Washington Accord.

During the period from 2003 to 2016, AEER accreditation center [8] accredited more than 400 education programmes offered both by Russian and foreign universities (fig. 1). The representatives of the Ministry of Education and Science of the RF, international accreditation agencies and professional communities were always involved into the accreditation process. More than 350 education programmes were awarded EUR-ACE label (fig. 2).

The education programmes accredited by AEER accreditation center are offered by the leading Russian universities which take the top spots in the national university ranking. The data on most of accredited programmes are available in the annual reference book "Best Educational Programs of Innovative Russia". The graduates of the accredited programmes are in a high demand among employers and usually move up quickly the career ladder.

For further development and advancement of multi-level systems of education quality assurance, in 2014 the accreditation center of AEER designed and implemented the criteria to accredit vocational programmes in the field of engineering and technology. The accreditation criteria and procedure are set in compliance with the international standards [7]. The accreditation was piloted in Tomsk Polytechnic Vocational School, Tomsk Vocational School of Information Technologies and Stary Oskol Technological Institute n.a. A.A. Ugarov (branch) National University of Science and Technology "MISIS".

University Ratings

Despite all the drawbacks of the university ratings (the examples are illustrated in the article by S.V. Ablamejko [9]), they provide not only subjective evaluation resulted from the current university reputation, but also a number of basic characteristics, such as highly-qualified faculty, qualitative training, up-to-date facilities and other parameters, i.e. the level of university performance, as a whole (though not always precise information). It is also believed that ratings

Fig. 1. The number of programmes accredited by AEER

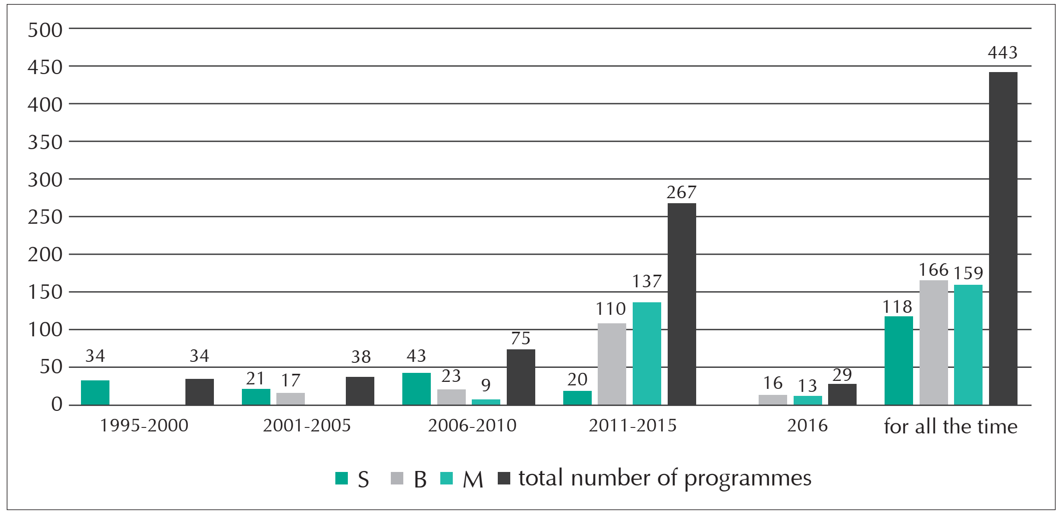
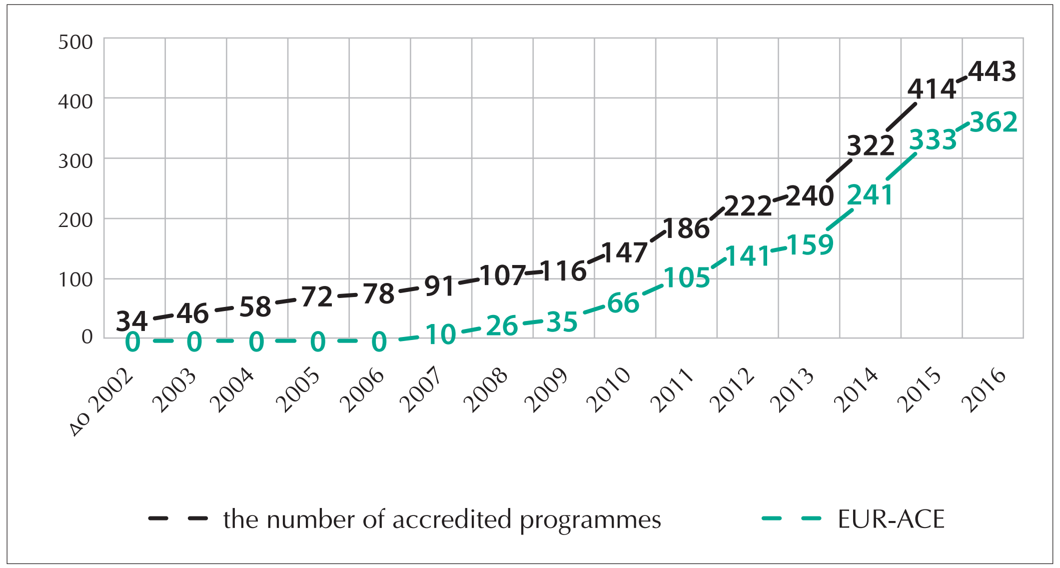


Fig. 2. The number of programmes awarded EUR-ACE label



contribute to enhancing education quality due to sharpening competition on the educational service market.

How often universities apply for accreditation and whether there is any dependence between the number of accredited programmes offered by university and its spot in the national ratings? To answer these questions, let us analyze the following examples.

All universities can be divided into three groups:

1. "Elite" universities basically need no approval of education quality; however, they take top spots in the national university ratings and have good reputation in the international university educational community.

Such universities include Lomonosov Moscow State University, National Research Nuclear University MEPhI, Bauman Moscow State Technical University, and Saint-Petersburg University.

2. The universities which are striving to become leading ones in the academic community, they accredit education programmes on a regular basis, participate in various national university ratings and federal programmes (project 5-100, "Staff for Regions", "Universities as Centers for Innovations", etc.).

This group involves National Research Tomsk Polytechnic University, National University of Science and Technology NUST MISiS, Higher School of Economics. Based on the comparison of the number of accredited programmes offered by these universities, let us analyze the proportion of the accredited programmes relating to the positon of the university in various university ratings (Table 1).

3. Finally, universities which demonstrate no interest in university ratings and do not participate in the governmental programmes.

As it is obvious, the table demonstrates no direct dependence of the university position in the national ratings on the number of accredited programmes. However, this issue requires more rigorous examination as it is quite complicated to undoubtedly identify the influence of this factor on the university rating. The accreditation of education programmes is an absolutely

Table 1. Relation of the number of accredited programmes to the university position in the national and international ratings

Universities from project "5-100"	National university rating (Interfax), 2016	Rating agency "Expert RA", 2016	QS World University Rankings, 2016	BRICS Rankings, 2016	EECA University Rankings, 2016	The proportion of accredited programmes (approximately, data are taken from open sources)
Higher School of Economics	6	6	411-420	62	35	0.55
National University of Science and Technology NUST MISiS	14	18	601-650	87	63	0.7
Saint Petersburg Electro-technical University "LETI"	22	36	not available	121-130	110-120	0.57
Tomsk State University	9-10	13	377	43	20	0.06
Tomsk Polytechnic University	9-10	8	400	64	45	0.63
ITMO University	12	19	not available	101-110	81	0.07

important facet of university life, especially of those universities which are interested in enrolling foreign students and offering joint programmes or double degree ones.

Additionally, global ratings evaluate university as a whole and, as a rule, they do not reveal the quality of certain education programmes (bachelor's, master's, and post-graduate programmes), as well as one can hardly learn from these ratings how actively a university implements new teaching technologies, for example, distance education. However, it is these issues that are of great interest for a potential enroller or employer. Therefore, the ratings based on certain university activities or programmes are becoming more and more popular.

Conclusion

In the context of global competitiveness, the quality of education becomes an essential factor that enables a certain person or the entire society to achieve and maintain the leading positions on the global market. The world and its values are in constant change, which means that education should also change (though not so rapidly) in order to meet the requirements and expectations of students who are definitely want to be in demand in the modern world.

The professional and public accreditation allows university authorities timely to respond to the ever-changing requirements of business and labor market. The accreditation criteria developed to assess the quality of education programmes stimulate development and advancement of education systems in line with the demands of society.

The basic benefits for the students attending accredited programmes were outlined.

Thus, in line with the above and in order to contribute to further enhancement of education quality, it is required:

- to continue accredit education programmes by international and domestic professional and public accreditation centers, including AEER;
- to make agreements between leading industrial corporations and accreditation agencies of Russia;
- to consider the results of professional and public accreditation of education programmes in the national university ratings;
- to involve as more as possible stakeholders in dealing with the issues of engineering education quality enhancement.

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REFERENCES

1. Ursul, A.D. Strategija nacional'noj bezopasnosti Rossii i obrazovanie dlja ustojchivogo razvitija [Strategy of national security of Russia and education for sustainable development]. Otkrytoe obrazovanie [Open Education]. 2009. No. 4. – pp. 63–73. (In Russ., abstr. in Engl.)
2. Birnbaum, R. The life cycle of academic management fads. J. of Higher Education. 2000. Vol. 71, No 1. – pp. 1–16.
3. Gerasimov, S.I., Shaposhnikov, S.O. Mezhdunarodnaja professional'no-obshhestvennaja akkreditacija inzhenernyh obrazovatel'nyh programme [International professional-public accreditation of engineering education programmes]. Saint-Petersburg: Publ. LETI, 2014. – 170 p. (In Russ.)
4. Shifrin, M.B. Setevye formy realizacii obrazovatel'nyh programme [Network forms of education programmes]. Uchenye zapiski mezhdunarodnogo bankovskogo instituta [Academic notes of international bank institute]. 2014. No 9. – pp. 82–85. (In Russ., abstr. in Engl.)
5. Zubareva, T.A. Jeffektivnost' modeli setevogo otkrytogo vzaimodejstvija obrazovatel'nyh uchrezhdenij kak resurs innovacionnogo razvitija [Efficiency of open network interaction of education institutions as a resource of innovative development]. Mir nauki, kul'tury, obrazovanija [World of science, culture, education]. 2009. No 5. – pp. 178–184. (In Russ., abstr. in Engl.)
6. Pokholkov, Yu.P., Chuchalin, A.I., Mogilnitsky, S.B. The national accreditation system for higher education institutions in Russia. Higher Education in Europe. 2002. Vol. XXVII. №. 3. – pp. 217–230.
7. Chuchalin, A.I. [i dr.] Kriterii i procedura professional'no-obshhestvennoj akkreditacii obrazovatel'nyh programme po tehnicheskim napravlenijam i special'nostjam [Criteria and procedure of professional-public accreditation of education programmes in the field of engineering and technologies]. Tomsl: TPU Publ., 2014. – 56 p. (In Russ.)
8. Akkreditacionnyj centr Associacii inzhenernogo obrazovanija Rossii Аккредитационный центр [Accreditation center of the Association for Engineering Education of Russia] [Jelektronnyj resurs]. Association for Engineeriing Education of Russia: site. – 2003–2017. – URL: http://www.ac-raee.ru/ru/ac_aeer.htm, free (accessed: 15.03.2017).
9. Ablamejko, S.V., Gusakovsky, M.A. Uchastie universitetov v mirovyh rejtingah kak faktor povyshenija kachestva podgotovki specialistov [Participation in international university rankings as a factor of improving the quality of teaching and learning]. Vysshee obrazovanie v Rossii [Higher Education in Russia]. 2013. No 5. – pp. 124–135. (In Russ., abstr. in Engl.).

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Analysis of Evaluation Criteria for Thesis

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The article addresses the problem of raising thesis quality. The authors specify what scientific research is, determine its peculiarities, introduce the evaluation criteria for thesis and provide a list of reviewers.

Key words: search, thesis, evaluation criteria for thesis, Dissertation Council, Dissertation Council's Commission, external reviewer, opponent.

At present, many scientists working on thesis are involved in development of new materials (nanomaterials); biofuels and lubricating oils for internal combustion engines; polymers for repair of tractors, cars, and harvesters; new crop varieties. A great number of scientists conduct research in the spheres of seeds encapsulation, plant production and technologies, intelligent systems for automatic and automated process control. However, it seems that more attention should be paid to environmental issues in order to ensure sustainable development for prosperous life today and in future.

Laser technologies are widely applied in surface hardening and annealing treatment, surface alloying and embedding in glass, developing different types of coating, improving welded joints. Ultra-high frequency apparatuses are used in the treatment of sick animals, milk and crop processing.

In any study field, there are many developments to make people's life prosperous.

The objective of scientific research is a comprehensive study of the object, process, or phenomenon, their structure, connections and relations by means of scientific methods and with appropriate devices and equipment applied. In addition, scientific research aims at obtaining and implementing the outcomes, which will contribute to society [1, p. 79].

Scientific research, in contrast to other types of investigation or testing, should always be topical, consistent, systemic, comprehensive, reliable, and unbiased, should provide evidences, be complete and reproducible. These aspects are related to the evaluation criteria for thesis [2, p. 384-385].

The research issue is considered topical if the society is interested in this research outcomes and their implementation. Therefore, it is essential to prove that the research is feasible, timely, preferred or desirable. In terms of economy, the investigation conducted can have customers, whose demands are directly connected with the research results and who are ready to implement research outcomes in their production. The topicality should be based on policy documents, economic and industrial plans, scientific trends and demand forecasts, as well as grants awarded by different funds [3].

The research is regarded as consistent if the high-quality outcomes can be obtained in a way which is less time and effort consuming than others. For instance, based on the previous research one can propose an issue and prove its topicality, determine research direction, subject, object, aim, objectives, theoretical foundation, testing methods and techniques, and also the place or area, where the outcomes will be implemented. Considering the relevant published materials, the scientist can formulate a scientific problem or task and suggest a hypothesis. Following the way described above, one reaches the aim of the research in a manner that is less effort-consuming.

The research is characterized as systemic when a scientist, over a whole period of study, takes into account as many as relevant factors as possible. The thesis is complete when the research outcomes are implemented; there are recommendations on how the results should be used or how the research can be continued in future, with a particular direction determined.

Logics is particularly important when scientists analyze theoretical and experimental data obtained in the course of the research. It is also essential when writing conclusion. The question "why did it happen?" is less important than the question "what is the relation between cause and effect?", in other words, the scientist should reveal the essence of the process or phenomenon. It is obvious that the results obtained should be proved.

"Learning without thought is labor lost; thought without learning is perilous" – Confucius.

The research results are comprehensive if the author indicates the conditions under which the results were obtained, a parameter space, operational modes, etc. All this is particularly important for project organizations involved in relevant devices and technologies production.

For the research results to be reliable and unbiased, the scientists should stick to indisputable and commonly accepted scientific doctrines, national and international, widely-known and widely-applied techniques, programmes, GOSTs and OSTs, cutting-edge devices and equipment, including those designed in the course of the research. It is also crucial to conduct a sufficient number of tests, secure concordance between theoretical proposals and experimental data, provide well-grounded conclusions, and make sure that there is no contradiction between the results obtained and the relevant data provided by independent sources. Every scientist should implement the research outcomes in educational process or production, participate in diverse scientific and practical conferences (and the reports containing reviews of research outcomes should be approved), and publish papers in the open press and peer-reviewed journals and issues recommended by VAK (the State Commission for the Academic Degrees and Titles). Research outcomes implemented in production are commonly regarded as unbiased.

Research results should always be reproducible in order to be discussed and verified. This means that one should indicate the methods and techniques applied in the course of the research, as well as describe testing conditions

Based on the research conducted, one can prepare candidate's or doctoral thesis, as well as research report. The evaluation criteria for thesis are unified and given in the Regulation on conferment of candidate's or doctoral degree passed by the Government of the Russian Federation, dated September 24, 2013, no. 842 (Regulation), GOST 7.32-2008 Research report. Structure and submission guidelines, GOST R 7.0.11-2011 Thesis and authors' abstract, GOST 2.105-95 Unified system of engineering documentation. The organization where the thesis was prepared and the organization-external reviewer, as well as the Dissertation Council's Commission, the opponents, the Dissertation Council are to check whether the text submitted meets general requirements to text documents, reviewers of author's abstract and research report, Scientific-Technical Council of the department (laboratory) and Scientific Council of the Institute.

Table 1 shows the evaluation criteria for thesis and author's abstract review.

The data in the table indicates that the quality of thesis, as well as reliability of research results, are thoroughly monitored. However, some thesis and author's abstracts still have limitations, which deteriorate the value of research outcomes and decrease the qualification level of the authors. The typical limitations are as follows: inaccuracies in thesis title; inappropriate aims, subject and

Table 1. Evaluation criteria for dissertations

Evaluation criteria	Organization		Dissertation Council's Commission	Opponent	Dissertation Council	Author's abstract review
	where thesis is prepared	external reviewer				
1	2	3	4	5	6	7
Theme, P. 23			+		+	+
Topicality, P. 23			+	+	+	+
Theoretical statement as scientific accomplishment, P. 9			+		+	+
Solution for scientific problem, P. 9				+		+
Well-grounded technical and other development solutions, P. 9			+		+	
Solving tasks significant for development of the relevant field of study, P. 9			+	+		+
Providing new scientifically-verified technical and technological solutions and developments, P. 9				+		+
Written by the author independently, P. 9	+					
Consistency, P. 9, P. 10					+	+
Providing unique research outcomes for the relevant field of study, P. 10				+	+	+
Author's personal input in science, P. 16, P. 25	+					+
Data on implementation of research outcomes, P. 10		+				+
Giving recommendations on implementation of research outcomes, P. 10			+			+
Evaluating the research outcomes in comparison with other well-known solutions and providing supporting arguments, P. 10			+	+	+	+
Publication of key research outcomes, P. 10, P. 25		+		+	+	+
Number of papers published in peer-reviewed journals, P. 13				+	+	+
References to the sources of the borrowed materials, P. 14				+	+	+
References to papers prepared individually and (or) in co-authoring, P. 14				+	+	+
Reliability degree of the research outcomes, P. 16, P. 23	+			+	+	+
Scientific novelty and practical relevance, P. 16, P. 24, P. 25	+				+	+
Significance of scientific work, P. 16	+			+	+	+
Correspondence between the thesis and the field of study, P. 16, P. 18	+			+	+	+
Completeness of the information provided in papers published, P. 16	+			+	+	+
Feasibility of scientific statements, conclusions, and recommendations provided by the thesis, P. 23				+	+	+
Meeting the criteria for thesis provided by the Regulation, P. 1, P. 23				+	+	+
Meeting the deadlines for placing announcement on defense in the Internet and thesis and author's abstract on the official site of the Dissertation Council, P. 1	+					

1	2	3	4	5	6	7
Following the regulations on thesis submission and defense, P. 26	+					
Verified and well-grounded conclusion and recommendations, P. 23				+	+	+
Significance for science and practical usage, P. 10					+	+
Literacy of thesis and author's abstract (GOST 2.105-95)					+	+

object of study; poorly revealed topicality, scientific novelty, practical implications, and results reliability; absence of or improperly executed documents proving implementation; clumsy conclusion; numerous spelling, syntactical, and stylistic mistakes (failing to comply with GOST 2.105-95). In general, about 40–50% of the submitted thesis fail to meet the criteria [4, p. 2356–2357].

It is for the Higher Attestation Commission (VAK) to decide whether particular thesis and author's abstract meet the relevant criteria.

Table 2 provides the reasons why the Higher Attestation Commission (VAK) does not approve the solutions of the Dissertation Councils on awarding candidate's and doctoral degrees in different sciences [5, p.1-2; 6, p.3; 7, p.4; 8, p.5; 9, p.6; 10, p.11; 11, p. 10; 12, p. 11; 13, p. 12; 14, p.13; 15, p.14; 16, p. 15; 17, p.16]:

- not meeting the deadlines for placing the thesis and author's abstract on the official website of the organization, in which the Dissertation Council is, and announcement on thesis defense on the official website of the Higher Attestation Commission (VAK), P. 26 of the Regulation – 10 degree-seeking applicants (45.4%);
- borrowing materials without references to the author and (or) source, P. 14 of the Regulation – 5 degree-seeking applicants (22.7%);
- upon the application of the degree-seeking applicant, P. 38 of the Regulation – 3 degree-seeking applicants (13.7%);
- fail to meet the criteria for thesis, P. 1 of the Regulation – 3 degree-seeking applicants (13.7%);
- inaccurate information on scientific publications provided in the author's abstract, P. 11 of the Regulation – 1 degree-seeking applicant (4.5%).

When interviewed, degree-seeking applicants claimed that thesis and author's abstract submission guidelines have never been explained to them. Scientific supervisors and consultants also support this statement.

More often than not, papers and guidelines considering thesis preparation provide information on how to choose the topic, make a plan, work with literary sources and choose the methodology, conduct theoretical and experimental investigations, etc. They neither suggest proper nor give examples of wrong titles, do not describe how deeply investigated an issue is, do not provide enough evidences of the novelty and reliability of research, etc. Therefore, at present, there is an urgent need in introducing the discipline "Methodology of thesis development and preparation" into post-graduate programmes. Post-graduate students do need manual providing examples on different parts of thesis, which do meet the criteria applied. Currently, one can hardly find a thesis which would meet 75–80% of quality requirements.

Table 2. Deprived scientific degrees: fields of study (2014–2015)

Field of Study	Paragraph	Doctor of Sciences (number)	Candidate of Sciences (number)
Law	1, 14, 38	3	
Philology	1	2	
Biology	11	1	
Medicine	26		5
Physics and Mathematics	26		1
Economics	14		4
Pedagogy	26 38		2 1
History	38		1
Technical Sciences	26		2
Total:		6	16

REFERENCES

1. Krutov V.I., Popov V.V. (eds.) Osnovy nauchnykh issledovanii: uchebnik dlya vuzov [Researc fundamenatls]. Moscow: Vysshaya shkola, 1989. – 400 p.
2. Kapustin V.P. Kriterii otsenki kachestva podgotovki dissertatsii [Elektronnyi resurs] [Evaluation criteria for thesis]. Koncept [Concept], 2016, vol. 15. – pp. 381–385. URL: http://e-koncept.ru/2016/86979.htm (Accessed 27.11.2016). (In Russ.).
3. O poryadke prisuzhdeniya uchenykh stepenei [Elektronnyi resurs]: posta-novlenie Pravi-tel'stva Ros. Federatsii ot 24 sent. 2013 g. № 842 [The Regulation on conferment of candidate's or doctoral degree passed by the Government of the Russian Federation, dated September 24, 2013, № 842]. Accessed in information and reference system "Kodeks".
4. Kapustin V.P. Povyshenie kachestva podgotovki dissertatsii i avtoreferatov [Elektronnyi resurs] [Improving quality of thesis and author's abstract]. Koncept [Concept], 2015, vol. 13. – pp. 2356–2360. URL: http://e-koncept.ru/2015/85472.htm (Accessed 28.11.2016). (In Russ.).
5. Ob otmene resheniya soveta po zashchite dissertatsii na soiskanie uchenoi stepeni kandidata nauk, na soiskanie uchenoi stepeni doktora nauk D 208.094.03, sozdannogo na baze Gosudarstvennogo byudzhetnogo obrazovatel'nogo uchrezhdeniya vysshego professional'nogo obrazovaniya "Saratovskii gosudarstvennyi meditsinskii universitet imeni V.I.Razumovskogo", o prisuzhdenii uchenoi stepeni kandidata nauk i ob otkaze v vydache diploma kandidata nauk: prikaz Minobrnauki ot 20 maya 2015 g. № 459/nk [Reversal of decision of Dissertation Council D 208.094.03 established in Saratov State Medical University n.a. V.I. Razumovsky on conferment of candidate's degree and withholding Diploma of candidate of sciences: the order by the Ministry of Education and Science, dated May 20, 2015, № 459nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 4. – pp. 1–2.
6. Ob otmene resheniya soveta po zashchite dissertatsii na soiskanie uchenoi stepeni kandidata nauk, na soiskanie uchenoi stepeni doktora nauk D 212.306.04, sozdannogo na baze Federal'nogo Gosudarstvennogo avtonomnogo obrazovatel'nogo uchrezhdeniya vysshego professional'nogo obrazovaniya "Severo-Vostochnyi federal'nyi universitet imeni M.K. Ammosova", o prisuzhdenii uchenoi stepeni kandidata nauk i ob otkaze v vydache diploma kandidata nauk: prikaz Minobrnauki ot 20 maya 2015 g. № 460/nk [Reversal of decision of Dissertation Council D 212.306.04 established in North-Eastern Federal University in Yakutsk on conferment of candidate's degree and withholding Diploma of candidate of sciences: the order by the Ministry of Education and Science, dated May 20, 2015, № 460nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 4. – P. 2.
7. Ob otmene resheniya soveta po zashchite dissertatsii na soiskanie uchenoi stepeni kandidata nauk, na soiskanie uchenoi stepeni doktora nauk D 001.036.01, sozdannogo na baze Federal'nogo Gosudarstvennogo byudzhetnogo nauchnogo uchrezhdeniya "Nauchno-issledovatel'skii institut kardiologii", o prisuzhdenii uchenoi stepeni kandidata nauk i ob otka-ze v vydache diploma kandidata nauk: prikaz Minobrnauki ot 20 maya 2015 g. № 462/nk [Reversal of decision of Dissertation Council D 001.036.01 established in Research Institute of Cardiology on conferment of candidate's degree and withholding Diploma of candidate of sciences: the order by the Ministry of Education and Science, dated May 20, 2015, № 462nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 4. – P. 3.
8. Ob otmene resheniya soveta po zashchite dissertatsii na soiskanie uchenoi stepeni kandidata nauk, na soiskanie uchenoi stepeni doktora nauk D 208.073.04, sozdannogo na baze Federal'nogo Gosudarstvennogo byudzhetnogo uchrezhdeniya "Rossiiskii kardiologicheskii nauchno-proizvodstvennyi kompleks", o prisuzhdenii uchenoi stepeni kandidata nauk i ob otkaze v vydache diploma kandidata nauk: prikaz Minobrnauki ot 20 maya 2015 g. № 465/nk [Reversal of decision of Dissertation Council D 208.073.04 established in Russian Cardiology Research and Production Complex on conferment of candidate's degree and withholding Diploma of candidate of sciences: the order by the Ministry of Education and Science, dated May 20, 2015, № 465nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 4. – P. 5.
9. Ob otmene resheniya soveta po zashchite dissertatsii na soiskanie uchenoi stepeni kandidata nauk, na soiskanie uchenoi stepeni doktora nauk D 212.056.08, sozdannogo na baze Federal'nogo Gosudarstvennogo avtonomnogo obrazovatel'nogo uchrezhdeniya vysshego professional'nogo obrazovaniya "Dal'nevostochnogo federal'nogo universiteta", o prisuzhdenii uchenoi stepeni kandidata nauk i ob otkaze v vydache diploma kandidata nauk: prikaz Minobrnauki ot 20 maya 2015 g. № 466/nk [Reversal of decision of Dissertation Council D 212.056.08 established in Far Eastern federal University on conferment of candidate's degree and withholding Diploma of candidate of sciences: the order by the Ministry of Education and Science, dated May 20, 2015, № 466nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 4. – P. 6.
10. Ob otkaze vydache diploma doktora nauk: prikaz Minobrnauki ot 3 iyunya 2015 g. № 550/nk [Withholding Diploma of doctor of sciences: the order by the Ministry of Education and Science, dated June 03, 2015, № 550/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 4. – P. 11.
11. O lishenii uchenoi stepeni kandidata nauk: prikaz Minobrnauki ot 10 avgusta 2015 g. № 916/nk [Deprivation of the Candidate of Sciences degree: the order by the Ministry of Education and Science, dated August 10, 2015, № 916/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 5. – P. 10.
12. O lishenii uchenoi stepeni kandidata nauk: prikaz Minobrnauki ot 15 sentyabrya 2015 g. № 977/nk [Deprivation of the Candidate of Sciences degree: the order by the Ministry of Education and Science, dated September 15, 2015, № 977/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 5. – P. 11.
13. O lishenii uchenoi stepeni kandidata nauk: prikaz Minobrnauki ot 15 sentyabrya 2015 g. № 978/nk [Deprivation of the Candidate of Sciences degree: the order by the Ministry of Education and Science, dated September 15, 2015, № 978/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 5. – P. 12.
14. O lishenii uchenoi stepeni kandidata nauk: prikaz Minobrnauki ot 15 sentyabrya 2015 g. № 979/nk [Deprivation of the Candidate of Sciences degree: the order by the Ministry of Education and Science, dated September 15, 2015, № 979/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 5. – P. 13.
15. O lishenii uchenoi stepeni kandidata nauk: prikaz Minobrnauki ot 15 sentyabrya 2015 g. № 980/nk [Deprivation of the Candidate of Sciences degree: the order by the Ministry of Education and Science, dated September 15, 2015, № 980/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 5. – P. 14.
16. O lishenii uchenoi stepeni kandidata nauk: prikaz Minobrnauki ot 15 sentyabrya 2015 g. № 981/nk [Deprivation of the Candidate of Sciences degree: the order by the Ministry of Education and Science, dated September 15, 2015, № 981/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 5. – P. 15.
17. O lishenii uchenoi stepeni kandidata nauk: prikaz Minobrnauki ot 15 sentyabrya 2015 g. № 982/nk [Deprivation of the Candidate of Sciences degree: the order by the Ministry of Education and Science, dated September 15, 2015, № 982/nk]. Byulleten' VAK [Bulletin of the VAK], 2015, no. 5. – P. 16.

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Quality of Further Professional Education: New Trends in Assessment and Recognition

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The article deals with the technology of independent assessment and recognition of quality of further professional education.

Key words: professional personality development, continuing professional development, education quality assessment, assessment tools.

Rapid development of society and technologies leads to new standards in education system. Today, any political or technological process is of interdisciplinary nature, which stipulates further development of relevant sciences and practices, as well as induces teamwork in reaching mutual goals. Although the educational and professional standards focus on a definite profile, universities and the academic staff are free in designing an innovative education process. For this purpose, they can use the best experiences of both national and international experts with due regard to the systems of education quality assessment provided by highly acknowledged organizations.

Professional development after graduation strongly depends on the activities. The term "professional personality development" means a conscious choice of professional profile and professional activities, which a person devotedly performs. Professional personality development implies various stages in continuing professional development (CPD), in other words, lifelong learning, which starts with primary focus and career guidance providing basic information on future profession in early ages.

At different stages of professional personality development, there are turning-points, i.e. short intensive transformations of professional mentality, rearrangements of professional activities and behavior patterns, changes of professional development trends. Turning-points imply setting new goals, introducing new activities, altering professional communication patterns, and sometimes, changing professional profile.

CPD seems to be an efficient way to overcome a turning point, as it contributes to professional adaptation and ensures development of professional skills thus improving the level of proficiency.

Moreover, CPD is also connected with psychological state since it ensures so-called comfort zone: a person involved in CPD feels self-confident, knows the ways to overcome challenges and find solutions, which increases the work quality.

In our research, we stick to the term "professionalization". As a rule, it means "the process of professional formation, which includes: choice of profession with due regard to personal qualities and abilities, learning professional rules and regulations, professional development and self-perception, personal contribution to professional profile, professional personality development" [1]. There are also other definitions, however, professionalization always implies lifelong learning and professional personality development.

Professionalization means that a person is continuously acquiring new knowledge and developing new abilities and skills. This process includes several stages: starting professional activities; self-development to meet professional education requirements and the qualification level; perception of necessity in continuing professional development, which, in its turn, determines professional goals, motives, position and contributes to professional satisfaction; absorption of professional culture [2].

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To get higher professional education does not mean to become a professional. Professional formation takes place in the course of professionalization comprising CPD, further professional education, and self-education.

We would like to emphasize a compensative role of further professional education. Further professional education is to fill the gap between education provided in secondary and higher education schools, on the one hand, and rapid development of the relevant industrial sector, on the other hand. The high qualification is determined by employers' demand and described in the form of essential knowledge, abilities, and competencies.

The profound changes in ICT, new priorities and forces on the educational service market have a strong impact on further professional education (FPE) [3-5].

On the one hand, FPE is in demand, since lifelong learning is a commonly accepted concept. On the other hand, changes in the form of education (a shift from formal to informal education) introduced new ideas on assessment and recognition of FPE quality, which are based on a new model of FPE quality comprising two major aspects – development of professional competencies and independent assessment.

Although the issue of monitoring of professional competency development is more or less investigated, the question of independent assessment of FPE quality is still topical. Following the global trend, Russia is involved in designing the system of independent assessment and recognition of learning outcomes, which currently includes three major constituents:

- professional standards;
- centers for independent qualification assessment in different economic sectors;
- professional and social accountability accreditation of education prog-rammes.

Social accountability accreditation of institute or university, as one of the types of education recognition, is implemented in Russia by means of quality management standards. Although the accreditation (ISO certification) is a voluntary procedure, it becomes more and more popular in Russian and abroad.

The logic is as follows: profound education (qualifications and competencies meeting particular requirements or professional standards) results from high-quality education process, which is provided by efficient performance of the educational organization.

Taking into account the ideas mentioned above, today it is important to develop all three types of FPE independent assessment and recognition:

- independent assessment of staff professional qualities;
- professional and social accountability accreditation of education programmes;
- social accountability accreditation of educational organizations.

The main goals of independent assessment of staff professional qualities are as follows:

- to give objective and professionally recognized conformity assessment, which is hold to determine that professional's qualification meet manufacturing and business require-ments prescribed by the professional standards; and
- to verify the professional's rights to perform the definite activities no matter where, when, and how the qualification was acquired.

The essential component of the independent assessment is adequate assessment tools.

For instance, the procedure of

professional testing can include several stages:

- knowledge and skills assessment, the analysis of evidences proving professional experience;
- assessment of relevant professional activity performance.

The assessment tools should be:

- **multifaceted:** the tasks should provide integrative assessment of knowledge, abilities, professional skills and experience of the candidate;
- **reliable:** assessment methods and tools should reveal all the aspects prescribed by the professional standards, and assessment itself should be based on unambiguous measurable criteria;
- **consistent:** assessment results should be adequate and reliable regardless of time, place, experts and candidates involved;
- **relevant:** the assessment tools should correlate with assessment goals (the tasks should be as close as possible to professional activities within the definite qualification).

Assessment tools can be different for various profiles. For instance, an efficient system of assessment tools designed for certification of managers and auditors by the European Organization for Quality is inadequate to assess the qualification level of engineers. The principle difference between the assessed skills makes it necessary to apply an alternative assessment methodology. In particular, to assess practical skills, Worldskills methodology is commonly applied.

Independent assessment is to ensure recognition of awarded professional qualification, as well as estimation of professional performance.

The whole complex of tools should make the qualification assessment results unbiased, reliable, and recognized by the professional unity (employers). This is particularly important for FPE, which is not proved by nationally recognized certificate and often includes informal education.

There are also other factors to be considered: fidelity of organizations and individuals providing FPE; the regulations and requirements to ensure competition and preventing abuse of right; moral and ethical criteria in the assessment of educational organization performance.

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REFERENCES

1. Psihologicheskij slovar' [Jelektronnyj resurs] [Dictionary of Psychology]. 2009–2016. Professionalizacija [Professionalization]. URL: http://vslovare.ru/slovo/psihologicheskiij-slovar//professionalizatzija (Accessed 29.12.2016).
2. Grishina E.S. Nepreryvnost' obrazovanija kak potrebnost' XXI veka [A formation continuity as requirement of the 21st century]. Voprosy kul'turologii [Issues of culturology], 2012, no. 1, pp. 61–65. (In Russ, abstr. in Engl.).
3. Anis'kina, N.N. DPO: nezavisimaja ocenka i priznanie kachestva [Additional fee-paid education: independent assessment and quality recognition]. Akkreditacija v obrazovanii [Educational accreditation], 2016, no. 1, pp. 52–54. (In Russ.).
4. Ivanov V.G., Barabanova S.V, Galihanov M.F. Novye tendencii gosudarstvennogo regulirovanija sistemy podgotovki povyshenija kvalifikacii kadrov v Rossijskoj Federacii [New trends in government control over the system of continuing professional development in the Russian Federation]. In Inzhenernaja pedagogika [Engineering Pedagogy]. Moscow: MADI, 2015, pp. 23–31.
5. Ivanov V.G., Barabanova S.V, Galihanov M.F. Innovacionnye formy setevogo obrazovanija v obrazovatel'nom pole Respubliki Tatarstan [E-learning innovations in the Republic of Tatarstan]. Setevoe vzaimodejstvie kak jeffektivnaja tehnologija podgotovki kadrov: sb. tr. Vseros. (s mezhdunar. uchastiem) nauch.-metod. konf., Joshkar-Ola, 30–31 okt. 2014 g. [Proceedings of the All-Russian scientific and methodological conference with international participation “Setevoe vzaimodejstvie kak jeffektivnaja tehnologija podgotovki kadrov”]. Yoshkar-Ola: Publ. Volga State University of Technology, 2015, pp. 52–57.

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Vocational Education and Training Schools in Terms of Student Migration in Russia: Challenges and Prospects

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The paper considers social, economic, and demographic effects of attracting foreign students to vocational education and training schools in Russia. The authors investigate challenges and prospects of increasing national share in the export of educational services in this sector.

Key words: student migration, vocational education and training schools, adaptation, integration.

The article presents the findings of the research project aimed at investigating and evaluating social, economic, and demographic effects of attracting international students to vocational education and training schools in Russia as a part of the programme to increase national share in the export of educational services in the medium and long term.

Priority of student migration development is enshrined in the Concept of State Migration Policy of the Russian Federation for the Period until 2025. However, the mechanisms to reach the migration priorities in vocational education are not effective [1]. To address this issue, it is essential to investigate challenges and prospects of attracting foreign students into Russian vocational education. This would permit a more complete description of the status of Russian education on the global market of vocational education services, which, in its turn, is required to develop adequate mechanisms for increasing and supporting competitiveness of the country on the global market. We believe that the income from the flow of international students into Russian vocational training schools (training colleges, vocational schools, etc.) is rather insignificant, whereas the potential for providing qualitative educational services is high. In addition, student migration could also contribute to increasing the number of skilled working age employees who are in demand on the labor market and have been successfully integrated into Russian society.

The possibility to establish certification centers on the basis of vocational training schools has not been adequately discussed yet. These certification centers would conduct the procedures aimed at recognizing and evaluating skills, knowledge, and competencies of migrants. It would be of great demand on the domestic and global market. Inclusion of Armenia and Kyrgyzstan into the Eurasian Economic Community (EAEC) customs union in 2015 offers additional opportunities for such retraining on the basis of international partnership. The position of Russia on the global education market has been strengthened over the past years. This is due to the steady increase in the number of international students, which is the result of the great project 5-100 aimed at supporting leading universities of the RF. Unfortunately, the same could not be said of vocational education.

Today, the Russian economy needs an influx of migrants. According to the forecasts from the Federal State Statistics Service

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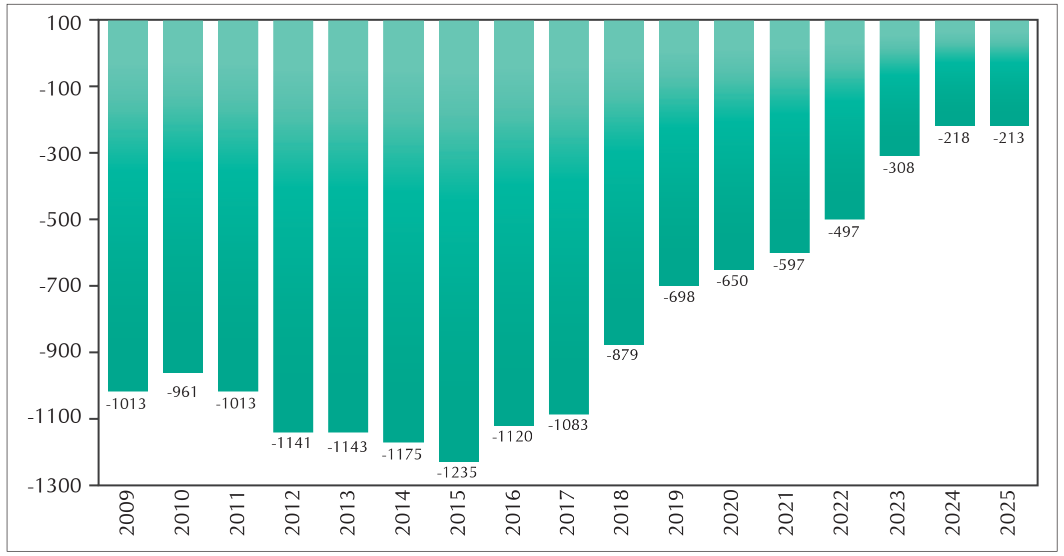
(Rosstat), the number of working age employees is decreasing in Russia (Fig. 1). The working age population is predicted to decline by 14 million people in 2009-2025.

The following objectives to attract migrants are stated in the State Migration Policy Concept of the Russian Federation [1]: "Migration flows into the Russian Federation is one of the ways to increase the population of the country in general and its regions in particular, while the attraction of qualified specialists and other foreign workers needed on the Russian labor market is an essential part of sustainable development of the country". The foreign students graduated from Russian vocational training schools, on the one hand, would make good the deficit of workers faced by the Russian economy over the past years, and, on the other hand, would contribute to dealing with the demographic imbalance in the country [2].

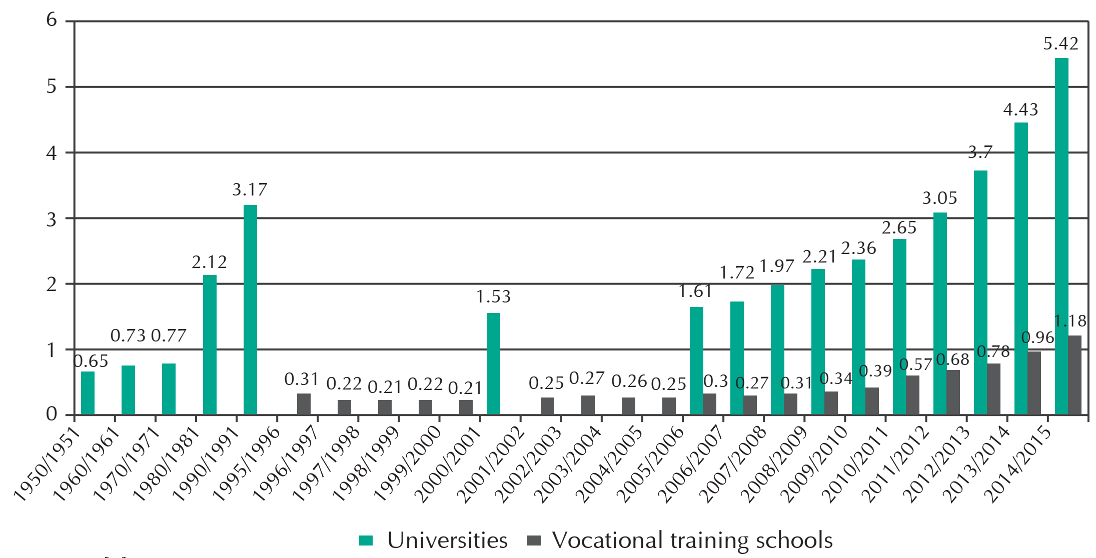
The overall assessment proves that there is certainly a high potential to increase the number of international students enrolled in vocational schools. In 2014/2015, 24.9 thousand of international students studied (full-time and part-time) at Russian vocational schools, representing 1.18% from the total number of students. At the same time, the Russian universities had the total undergraduate enrollment of 5209, including 282.9 thousand of international students (5.42%). Benefits to the RF economy from the international students increased 7 times and by the end of 2015 reached 73 billion rubles. Thus, it can be stated that the education sector is not only cost intensive, but also export-oriented [3]. It is worth noting that the number of international students hosted by Russian vocational training schools is rather small, and the annual growth of its share in the total number of students is slow (Fig. 2). Increasing global competition for international students accounting for approximately 5.1. million people (according to the data of Institute of International Education) is one of the trends that fosters national economies to develop international education. The share of Russian education on the global market grows slowly, therefore, the emphasis in elaborating the strategies for vocational education development should be made on the increasing number of students from the Commonwealth of Independent States (CIS) [4].

Fig. 1. Decline in working age population in Russia in 2009-2025 (Rosstat)



Source: Rosstat data

Fig. 2. The proportion of foreign students in total student number in vocational training schools and universities from 1950 to 2015 in RSFSR/RF, thousand people.



Source: [3].

The current research is predominantly empirical and based on the interviews: 40 expert interviews and 40 in-depth interviews with the international students studying at the vocational training schools were conducted in Tomsk, Ekaterinburg, and Moscow from March 2016 till August 2016. The experts include scholars, faculty members of vocational training schools, relevant authorities, and potential employers. The interview instrument was developed as a flexible guide, including sets of questions that cover various aspects of international student enrollment into the vocational training schools of the country. The interviewed international students were basically from CIS: Kazakhstan, Kyrgyzstan, Tadzhikistan, Azerbaidzhan, Uzbekistan, Ukraine, and Armenia.

The current state of research on international student flow into Russian vocational training schools

The issue of international student flow into Russian vocational training schools has not been adequately addressed yet. In contrast to government-supported higher education, vocational education in Russia and precisely the number of international students enrolled in such schools are beyond the scope of scientific interest. The lack of research on this issue proves this fact. Most of the studies which focus on student migration basically concern higher education (Zh. Zayonchkovskaya, A. Aref'ev, L. Ledeneva, O. Korneev, Mukomel', etc.). There is no research that investigates social, economic, and demographic effects of attracting international students to vocational education and training schools in Russia. Foreign scholars also state that the issues of student migration within the vocational education and training programmes (VET, ISCED levels 3-4) have not been studied well in comparison with that within other education programmes [5]. The existing research carried out by Russian scholars basically focuses not on investigating practical aspects of and benefits from enrolling international students in Russian education institutions, but on evaluating scientific potential of the RF and the risk of "brain drain", i.e. the problems which are peripheral to the issue of the status of Russia on the global education market. In addition, these studies do not contribute to managing the existing facilities efficiently, which is of particular importance in developing the migration policy oriented to the support of international student flow into Russia. This focus is essential today given the current state of the Russian education and science.

The statistical book by A.L. Arefiev, F.E. Sheregi "Export of educational services in Russia" (2016) presents a large amount of factual data and statistical information about student migration into Russia. It also includes data on the number of international student enrolled in Russian vocational training schools in 1995/1996–2014/2015 academic years. In addition, the book outlines the courses "Russian for Foreign Students" provided the Centers for Russian Science and Culture and representatives of the Federal Agency for the Commonwealth of Independent States Affairs, living abroad compatriots [3]. The research presented in book "Study migration from the Commonwealth of Independent States and Baltic States: potential and prospects for Russia" (2012) is also noteworthy. Based on the large factual data, the authors have summarized the trends in student migration into Russian universities and outlined its prospects [6]. The research carried out by D.V. Poletaev and S.V. Dement'eva also focuses on student migration and international student adaptation at the universities of Moscow, Tomsk, and Krasnoyarsk [7 -9].

However, the findings of the above-mentioned research are not sufficient to provide complete description of the possibilities to attract international students into Russian vocational training schools. This is due to the fact that universities and vocational training schools train specialists for different labor market segments, offer different education programmes, and, as a result, have distinct niches on the global education market [9].

The main limitation of the discussed research is that authors concentrate on this or that aspect of student migration within higher education instead of analyzing this issue from the point of possible benefits from the flow of international students into country. This stipulates the investigation of Russian professional education market within the framework of the international professional training standards. The main purpose of this research is to contribute to an inflow of skilled workers and attraction of investments into the vocational education [9]. Therefore, despite the fact that it is far from being finished, the current research is rather relevant and is of particular practical interest.

Law enforcement practice: review

The number of cases in which foreign citizens (students of vocational training schools) are involved is insignificant. According to the Consultant Plus legal reference system, there were only 5 court judgements as at February 2017, including a judgement by the Supreme Court of the RF, 2 judgements of the court of general jurisdiction, and 2 judgments of Moscow courts and courts of Moscow region. In all cases, legal proceedings were initiated to challenge administrative court decisions concerning illegal working. The court judgements were analyzed in accordance with the procedure to monitor and maintain law reinforcement, approved by the Decree of the Government of the RF from 19 August, 2011 N 694, and the criteria developed within the current research:

1). Asserted claim.

2). Violated/challenge right.

3). Challenge decision, acts or omissions of the officials against international students enrolled in vocational training schools.

4). The core of court judgement, i.e. whether violation has been found or not, the claim has been sustained or not.

5). The revealed conflicts of law norms, mistakes of technical and legal nature, varying interpretations of law norms, violation of judicial practice uniformity.

6). Final evaluation and recommendations.

The list of the studied judicial acts published in the Consultant Plus legal reference system is given at the end of the article [10-12].

As protection of foreign students' rights is of practical value, the judgement by the Supreme Court of the RF from 30 June, 2016

N 78-AD16-30 is of particular interest. The Supreme Court sided with a foreign student enrolled in one of the vocational training schools.

The Court found the third-year student guilty of having committed administrative offence under article 18.10, part 2, of the Administrative Offences Code of the RF "Illegal work by a foreign citizen or by a stateless person in the Russian Federation", and imposed a fine of 5 000 rubles and rendered the decision on administrative expulsion of a student from the Russian Federation. The defense objected to this decision and requested the Court to revoke them and close the case. It was found during the trial that the student, a citizen of Turkmenistan, was performing work without corresponding permits or patent for work in summer 2015. This fact served as a ground for bringing her to administrative liability. The case file shows that she was a third-year student (full-time mode of education)) of the vocational training school in a specified period.

According to par 1 article 13.4 and par 6, 4 article 13 of Federal Law № 115-FZ "On the Legal Status of Foreign Citizens in the Russian Federation", a foreign resident who is undergoing general education course and reached the age of fifteen has the right to enter into employment agreement during vacation period without a work permit. In this proceeding, the Supreme Court decided that there was no evidence of illegal employment, and the administrative charges against a foreign student were not proven. The defense's complaint was satisfied, whereas the rights of the foreign student were restored. The increase in legal competence among international students is noteworthy. The analysis of the cases has revealed that international students actively defend their rights and seek advice and guidance from the relevant legal offices. The remaining court judgements were not found in international students' favor - a fine of 5000 rubles was imposed on students with administrative deportation from the territory of the Russian Federation.

Challenges and prospects for stipulating international student migration into Russian vocational training schools

The current research has revealed that Russian vocational training schools and the whole system of vocational education are not ready to enroll international students. In order to sustain a strong market position in the Commonwealth of Independent States and the Baltic States, significant investments in the sector of vocational education, as well as development of a long-term target-oriented programme "Promotion of international student mobility within vocational education" are required. In modern global society, migrants and their children can choose any country to study. Therefore, the vocational education programmes offered at Russian training schools should meet the international education standards. In addition, vocational training schools should be adequately equipped, have up-to-date facilities and skilled faculty members. Various preparation courses including Russian language training should be available for international students. The experts interviewed noted that many vocational training schools are trying to enter the market of the Commonwealth of Independent States and the Baltic States independently without any support from the Government. However, most of them are not on track to do so. Unlike vocational education, higher education institutions actively cooperate with the Commonwealth of Independent States. Most international students studying in Russia are from the Commonwealth of Independent States (the situation is similar for vocational education), Kazakhstan being a major sending country (roughly 1 in 4 international students studying full-time or part-time in Russia are from Kazakhstan). The standard-bearers of the Russian education abroad are Joint Slavonic Universities in Kirgizia, Belorussia, Tadzhikistan, and Armenia. Over the past three years, the Ministry of Education and Science of the RF has provided support to these countries by implementing development programmes in cooperation with Russian universities [3]. The similar cooperation pattern can be implemented within the vocational education. To bring Russian vocational training schools onto the global education market, the embassies and consular posts could possibly initiate shows and conventions of educational programmes offered by the Russian vocational schools. In addition, the existing migration legislation also poses significant challenges to the vocational education in Russia. The interviewed experts expressed the opinion that the staff of vocational training schools should also involve the position of a passport officer to register the international students. Such a post is provided only in the institutions which offer international students campus housing. It is a great challenge for a vocational training school to employ a person to register international students. Therefore, we believe that Russian vocational training schools are still not ready to enroll a large number of international students. Another factor to be taken into consideration is that labor migrants also make money to pay for children's education. Obviously, the education system of the RF can count on this finance. However, the main problem is that most labor migrants wish their children could receive a better job. They wish their children could work at offices and have a possibility of career growth. On the one hand, this fact is in line with the interest of Russia in qualified workers. Skilled labor jobs can pay well, even very well if an employee is constantly improving his/her qualification. On the other hand, the career expectations that most migrants have for their children are far from the reality. They are trying to help their children attain higher education, however, having graduated from universities, these international graduates could hardly find a job in Russia. This is due to that fact that the only niche for them on the labor market of Russia is worker occupations and positions of mid-level specialists. High tuition costs in polytechnic and sport colleges are of great concern. This fact forces migrants to choose the degree programmes with tuition and fees that cost less, i.e. humanitarian programmes. However, most of them are not in demand on the labor market. Relating to this issue, it would be essential to conduct career guidance in the countries that are major senders of international students. The main purpose of this career guidance is to explain the advantages of vocational education in terms of future employment in Russia. The economy will always need skilled worker even in a case of economic stagnation. The interviewed experts expressed the view that vocational education for international students can be both fee-paid or free. They can study for free within the framework of the interstate agreements between the Eurasian Union and the Commonwealth of Independent States. In this case, education is free only for students, the country itself will pay tuition fees for their citizens. The question is whether the Russian Federation is ready to pay tuition fees for the international students who would return to their native land after graduation. This question requires taking a reasonable decision at the Government level. Despite the fact that the majority of migrants from Central Asia come to Russia in search of work, there are certain risks not to see concrete efficiency gains from the investments made. There is also another possibility to foster the influx of international students into the Russian vocational training schools, i.e. to attract financial support from the potential employers. However, the employers are not willing to invest money into training migrants, they are waiting support from the Government that will bring up new workers for the labor market of the country. Thus, there is continuing tug-of-war between the Government and employers. Therefore, it is reasonable to rely on the money of migrants themselves who save for their children's education or retraining. The main task is to convince them that to invest money into vocational education is economically reasonable as qualified workers are always in demand even in the current fragile economic environment. In this context, the opening of representative offices of the vocational training schools abroad (similar to higher education when students study in their native country and have an opportunity to obtain Russian university diploma) is rather promising. It is possible to count on money which labor migrants send back to their families in their country of origin. A special attention should be paid to dissemination of the information about Russian vocational education. A role of the Government, as a main coordinator of economic development of the country, is of particular importance. As known, economic development of the country depends on the qualified foreign workforce. Priority of student migration development is enshrined in the Concept of State Migration Policy of the Russian Federation. This fact is obvious for everyone, however, the theory is inconsistent with the real actions aimed at attracting international students to the Russian vocational training schools.

To sum up, the most significant findings to emerge from this study are as follows:

1. Based on the in-depth interviews with the international students studying at the vocational training schools of the RF, social, economic and demographic aspects of student migration were revealed.

2. The lack of research focused on social, demographic, economic, and humanitarian benefits from the international student flow into Russian vocational schools was identified. Therefore, the approaches developed by foreign and Russian scholars to analyze study migration within the higher education from 2008 to 2016 were applied. The foreign scholars also emphasize the fact that the issues concerning international students' enrollment into vocational training schools have not been adequately addressed. This makes the current study relevant.

3. The research proved that the vocational education in Russia is not ready for a great influx of study migrants. Nevertheless, it is worth noting that the possibility to study at Russian vocational schools has already become attractive for young migrants due to new perspectives in finding job or even applying for citizenship. Earlier and more intensive career advice and guidance in the countries which are the basic senders of study migrants would, on the one hand, contribute to the increase in the number of in-demand qualified workers on the labor market and, on the other hand, assure additional financing to the vocational training schools.

4. The challenges to be addressed in order to attract the influx of international students into Russian vocational training schools:

a) Recruiting talented specialists who will be able to improve vocational training in accordance with the international education standards.

b) Enhancing the existing facilities of vocational training schools to guarantee high quality of student teaching. This will require serious financial injections.

c) Student internship should be regulated at legal level so that vocational schools do not face any challenges in its implementation and reinforcement.

d) Receiving assurance from potential employers or countries (both RF and native countries of migrants) that the money spent on migrant education will be reimbursed.

e) Similar to student migration in higher education, it is required to develop an effective regulatory device that would include a possibility of employer-sponsored education of migrants within the sector of vocational training.

5. Many Russian vocational training schools are trying to enter the education market of the Commonwealth of Independent States independently, without any support from the Government, and have already gained certain experience. Assistance in advertising, promoting (shows and conventions of educational programmes) Russian vocational education in the Commonwealth of Independent States by the embassies and consular posts would significantly contribute to fostering student migration into Russian vocational training schools.

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REFERENCES

1. Koncepcija gosudarstvennoj migracionnoj politiki Rossijskoj Federacii na period do 2025 goda [the Concept of State Migration Policy of the Russian Federation for the Period until 2025] [Elektronnyi resurs]: approved by the President of the RF 13 June, 2012, available at the Consultant Plus legal reference system. (In Russ.).
2. Bondarenko N.V. Rynok truda i professional'noe obrazovanie – kakov mehanizm sotrudnichestva? [Labor market and vocational education – what is the way to interact?] [Elektronnyi resurs] Monitoring jekonomiki obrazovanija [Monitoring of education economy]. Moscow: GU-VShE, 2007. № 8 (31). 104p. – URL: https://memo.hse.ru/data/2011/05/19/1213863051/infbul31.pdf, free (accessed: 11.05.2017).
3. Jeksport rossijskih obrazovatel'nyh uslug. Min-vo obrazovanija i nauki Rossijskoj Federacii [Export of educational services in Russia. The Ministry of Science and Education of the Russian Federation]. Moscow: Sociocentr, 2016. Isuue 6. 408 p. (In Russ.).
4. Dannye Instituta mezhdunarodnogo obrazovanija [The data of International Education Institute][Elektronnyi resurs]. Available at: http://www.iie.org/Research-and-Publications/Project- Atlas#.WM__mDvyiCg. (accessed: 05.03.2017).
5. Vocational education and training to counter social exclusion – stakeholder meeting report [Elektronnyi resurs] SIRIUS network: [website]. – [S. l.]: SIRIUS Network, cop. 2017. – URL: http://www.sirius-migrationeducation.org/vocational-education-and-training-to-counter-social-exclusion-stakeholder-meeting-report,(accessed: 06.03.2017).
6. Gavrilov K.A., Yatsenko E.B. Uchebnaja migracija iz stran SNG i Baltii: potencial i perspektivy dlja Rossii [Student migration from the the Commonwealth of Independent States and the Baltic States: potential and prospects]. Moscow: Nasledie Evrazii, 2012. 210 p. (In Russ.)
7. Poletaev D.V., Dement'eva S.V. Innovacionnye strategii razvitija mezhdunarodnogo obrazovanija v rakurse uchebnoj migracii v vuzy Rossii [Innovation development strategies in international education in terms of student migration into Russian universities] Izvestija Tomskogo politehnicheskogo universiteta [the Bulletin of Tomsk Polytechnic University]. 2010. Vol. 316, № 6. pp. 128 – 134. (In Russ., abstr. in Engl.).
8. Dement'eva S.V. Social'no-pravovye aspekty uchebnoj migracii v kontekste reformy rossijskogo obrazovatel'nogo zakonodatel'stva [Social and legal aspects of student migration in terms of Russian education legislation reform] Izvestija Tomskogo politehnicheskogo universiteta [the Bulletin of Tomsk Polytechnic University]. 2011. Vol. 319, № 6 pp. 166–172. (In Russ., abstr. in Engl.)
9. Poletaev D.V., Dement'eva S.V. Zurabishvili T.Z. Potencial uchebnoj migracii v professional'nye obrazovatel'nye organizacii v kontekste novoj migracionnoj politiki [Potential of student migration into vocational training schools in terms of new migration policy] 2014. Vol. 324, № 6. pp. 118–125. (In Russ., abstr. in Engl.)
10. Postanovlenie Verhovnogo Suda RF ot 30.06.2016 № 78-AD16 [Judgement by the Supreme Court of the RF from 30.06.2016 № 78-AD16] [Elektronnyi resurs], available at the Consultant Plus legal reference system.
11. Postanovlenie Moskovskogo gorodskogo suda ot 20.02.2016 № 4a-100/2016 [Judgement by Moscow Court from 20.02.2016 № 4a-100/2016]. [Elektronnyi resurs], available at the Consultant Plus legal reference system.
12. Postanovlenie Moskovskogo gorodskogo suda ot 20.08.2014 № 4a-2138/14 [Judgement by Moscow Court from 20.08.2016 № 4a-2138/14] [Elektronnyi resurs], available at the Consultant Plus legal reference system.

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Career Guidance and Counseling to Develop Engineering Education at School and University: Technologies and Models

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The paper deals with psychological and pedagogical aspects of engineering career guidance provided for pupils. It describes the experience of Elabuga Institute, Kazan Federal University, where they efficiently implement career guidance activities and develop engineering education based on interaction between school and university. One of the priorities is to involve pupils into research and technical activities through participating in innovation projects developed by the university.

Key words: career guidance, engineering education, engineering professions.

It is becoming more and more essential in Russia that school leavers should choose engineering as a future career. The current engineering education is intended not only to provide the required number of engineers for enterprises, but also to develop a special class of creators aimed at transforming an objective environment by implementing scientific and technical innovations [1].

Here we defined engineering education as a specially organized educational and training process at all levels of general education (including preschool one) and higher education. In this case, forms, methods and content of the educational activity aim at developing trainees' engineering thinking and their wish to become an engineer.

As V.V. Putin sais, an engineer is a high-qualified expert who ensures not only maintenance of hi-tech equipment or design modern facilities, but also construct surrounding reality [2]. Thus, the quality of engineering staff is a key factor of the nation's compatibility. The task of engaging the youth in engineering careers is important for Tatarstan as well. Its economy is quite dynamic: new business projects are being developed, the production capacity is growing. The lack of engineering staff may strongly impede the economical development of the republic. This fact necessitates considering new approaches to career counseling management at schools in order to develop sustainable interest in engineering jobs with regard to real labour market demand.

Career guidance is considered to be one of the most important school pedagogical activities. Career choice can be an important condition of happiness and well-being of a person; so, career guidance and counseling are in focus of research conducted in Russia and other countries [3-8].

The most popular jobs in our society have been a lawyer, an economist, and a manager for a long period. Thus, a lot of school leavers aimed to get a degree in these majors. A traditional career guiding scheme "want-can-must" failed to work, since "must" was omitted because neither students nor their parents were interested in the demand for the jobs on the labour market. No matter how motivating "want" and "can" might be, they did not guarantee proper employment.

The modern postindustrial society requires school leavers not only to know textbook information and solve standard test tasks, but also to develop personal qualities that would condition successful teamwork, self-development, continuous improvement and professional mobility. According to S.V. Malin and A.Y. Kozevnikov, the postindustrial society is characterized by the fact that a person manages his/her professional career, and the success criterion is a subjective value of personal awareness of success, or "psychological success" [9, p. 147]. There is no doubt that most school children dream of the job that would bring them not only financial satisfaction, but a moral one. They would like to be engaged in the activities they like and succeed in. Very few of them would like to perform physical work, which is quite reasonable in the light of social values of the XXI century. Thus, one of the important current pedagogical goals is to prepare school children for future professional activity of intellectual and creative character. Nowadays, it is intellectual work that makes basic contribution to the prosperity of any developed country.

Intellectual work is defined as a creative activity that requires intellectual energy to treat information and create new knowledge relating to important social value or hi-tech production [10, p. 212]. It follows that only creative people with non-standard thinking can be engaged in intellectual professional activity; they also should be well educated and smart. These features should be developed at schools; and the school career guidance should be of innovative nature.

A school subject "Handicraft" aims at facilitating professional choice of schoolchildren; it allows them to know more about different jobs and make future plans [11]. Besides, these classes make it possible for children to develop creativity and productive skills, and acquire learning and practical experience; these are the skills that constitute the base for the key universal competencies required for any activity.

However, as practice shows, the course of "Handicraft" does not always prepare schoolchildren for conscious choice of future professional career. There are several reasons for it, with one of them being poor teachers' awareness about modern labour market demands.

To indentify professional intentions of modern schoolchildren, we made a survey among schoolchildren of the ninth grade at schools in Naberezhnye Chelny, the Republic of Tatarstan. 46 schoolchildren were interviewed, 24 girls and 22 boys, aged 15-16 years old.

When asking "What are the most demanded jobs nowadays?", we received the following answers: an engineer (76% of the interviewed), a doctor (48%), a lawyer (22%), a teacher (22%), car mechanic (20%). The answers show that the schoolchildren in Naberezhnye Chelny assess the labour market demands adequately.

We were also interested in personal career choice of the interviewees. The question "Which jobs appeal to you?" was answered as follows: a psychologist (17%), a manager (15%), and an engineer (13%). A car mechanic, a journalist, a teacher, a policeman, and a lawyer got 9% each.

Although an engineering career is considered to be in demand, it is not chosen by many schoolchildren. They explain it by the fact that this job is too demanding in terms of high intellectual skills, personal responsibility, accuracy and punctuality in task performing.

Our questionnaire contained the following question: "Did "Handicraft" help you to know your abilities and choose your future professional career?". Only 30% of the schoolchildren gave a positive answer, which proves that unfortunately, teachers of handicraft cannot be called efficient career counselors.

Thus, it should be noted that all the applied methods of career guidance and counseling are not efficient. For example, participation of senior schoolchildren in academic competitions does not always facilitate their career choice. Successful school children have to participate in numerous academic competitions, since teachers choose the most capable and responsible children without taking into consideration their academic workload. As a result, instead of developing the strongest abilities of a pupil, his/her aptitude" is torn into pieces".

This statement is proved by the result of the survey conducted among the participants of the regional round of the All-Russia academic competition in "Handicraft", Kazan', 2015. 63 pupils of 10-11 grades, schools of the Republic Tatarstan, were interviewed.

When asking the question "What other academic competitions apart from "handicraft" did you take part?", we received the following answers: biology – 28.6%, geography – 27%, physics and the Russian language – 23.8%, mathematics, history and literature – 12.7% for each subject. The result can be explained either by a wide range of the schoolchildren's interests, or by the fact that their teachers make them participate in academic competitions in various subjects. The question "What competition do you consider to be the most interesting and useful for you?" was answered as follows: handicraft – 81%, physics – 47.6%, mathematics – 33.3%, the Russian language – 27%, biology– 22.2%, geography – 20.6%. These answers proved the fact that the schoolchildren participating in the regional round of handicraft competitions are mostly focused on science. They can also have aptitude for technical subjects.

The teachers of "handicraft", who were present at the competition, state that schoolchildren can really succeed in the subject if they are highly focused on it. The competitions in handicraft differ very much from those in other subjects, since handicraft requires not only intelligence, but also creativity and project skills, which is of vital importance for a modern engineer. It also should be highlighted that almost all the participants do like performing project work in handicraft (98.4%). Thus, to involve schoolchildren in project activity, and to motivate them to develop their intellectual and creative skills via academic competitions are an effective form of career guidance and counseling at school.

Besides, the interviewed teachers consider it useful to apply interactive educational technologies that favour successful career choice. These technologies involve business and role plays, psychological trainings, group discussions, disputes and debates, case-study, brain-storming, etc. These methods allow the teachers to involve schoolchildren in the activity that develops goal-setting and planning skills; communicative and social competencies.

Pedagogical universities can support career guidance and counseling at schools. For example, Kazan' Federal University (KFU), Elabuga Institute, provides a regular support and development of engineering education in the framework of the model "University – school". It regularly organizes academic competitions, summer and vacation schools, conferences, and educational courses for schoolchildren of 7-11 grades.

Schoolchildren are engaged in research work and engineering activities within the framework of the following projects:

- University for children.
- Summer camp "Intelleto".
- Summer physics and mathematics school.
- Center of educational robotics.
- Vacation school.

There are courses in drawing for 9-11 grades, and preparation courses for United State Exam (USE) in mathematics and physics for 10-11 grades. The university provides preparation for municipal and regional academic competitions in mathematics "Gifted children". The participants of the regional and final rounds of the All-Russia competition in handicrafts are supported and consulted.

Elabuga Institute (KFU) holds on an annual base the following events:

- Trans-regional scientific universiade for schoolchildren, 9-11 grades, (handicraft, IT, physics, mathematics, and biology).
- Open competitions in robotics.
- Trans-regional competition in handicraft "Creative work of schoolchildren".
- Project competition in technical work, 7-11 grades.
- Academic competition in drawing, 7-8 grades.
- Scientific conference in mathematics "Student + School pupil".
- Scientific schoolchildren conference in physics and mathematics "Mathematics and physics in modern information environment".
- Scientific schoolchildren conference in IT "Me and the Internet of the future".
- National scientific schoolchildren conference "Biological sciences: past, present, and future".
- Internet-competition for schoolchildren in IT.

The exhibitions of technical creativity of schoolchildren and students are held every year on the base of engineering-technological faculty.

Thus, career guidance and counseling conducted by Elabuga Insitute (KFU), contributes to the promotion and development of robotics and technical creativity of teenagers, enhance prestige of engineers via technical workshop and scientific conferences for children. There is a mechanism that creates a motivating environment ensuring teenagers' interest in mechanics, mathematics, and science. It also provides motivation for knowledge, research and project activities, technical work and awareness of contemporary technologies. Close integration of formal education (basic education programmes that implement the federal state education standards) and informal one (general and professional programmes of additional education for deeper knowledge and improved skills allows developing more flexible and adaptive technologies of career guidance and counseling.

REFERENCES

1. Kotova N.V., Osipov P.N. Stimulirovanie professional'nogo samoopredeleniya shkol'nikov k polucheniyu inzhenernogo obrazovaniya [Stimulating engineering career choice of schoolchildren]. Obrazovanie i pedagogicheskaya nauka v modernizatsii rossiiskogo obshchestva [Education and pedagogical science in modernizationof Russian society]. Moscow: Publ. ITIP RAO, 2012, pp. 330-336. (In Russ.)
2. Putin V.V. Stenogramma zasedaniya Soveta po nauke i obrazovaniyu 23 iyunya 2014 goda [Transcript of the meeting of the Board on science and education, 23 June, 2014]. http://www.kremlin.ru/events/ president/news/45962 (Accessed 11.05.16).
3. Dehaas J. Students like diploma-degree option at Guelph-Humber. The Maclean's Guide to Universities. http://www.macleans.ca/education/university (Accessed 14.08.2014). (In Engl.)
4. Demoulin E., Murphy J. Representations temporelles et decision dans la relation de conseil en orientation scolaire. Lorientation scolaire et professionnelle. 2005, vol. 34, no 4, pp. 479-498. (In Fr.)
5. Hughes K.L., Bailey Th.R., Karp M.M. School-to-work: making a difference in education. Phi Delta Kappan. 2002, no 4, pp. 272-279. (in Engl.)
6. Razumova M.V. Proforientatsiya v Rossii: stanovlenie, problemy, perspektivy [Career guidance in Russia: development, challenges, prospects]. Professional'noe obrazovanie i obshchestvo[Professional education and society]. 2014, no.3 (11), pp. 49-57. (In Russ., abstr. in Engl.)
7. Tolstoguzov S.N. Opyt proforientatsionnoi raboty za rubezhom [International experience in career guidance]. Obrazovanie i nauka [Education and science]. 2015, no., 1(120), pp. 151-165.
8. Faizrakhmanova A.L. Formirovanie proforientatsionno znachimoi kompetentnosti u uchashchikhsya srednikh klassov obshcheobrazovatel'noi shkoly [Development of professional valuable competency at secondary schools].Avtoreferat dis. kand. ped. Nauk [Dissertation theses]: 13.00.01. Ioshkar-Ola: Publ. Mariiskii gosudarstvennyi universitet, 2014, 23 p.
9. Malin S.V., Kozhevnikov A.E. K voprosu o spetsifike proforientatsii v postindustrial'nom obshchestve [Career guidance in postindustrial society]. Teoriya i praktika obshchestvennogo razvitiya [Theory and practice of public development]. 2010, no.3, pp. 144-148. (In Rus., abstr. in Engl.)
10. Bardina I.V., Zemlyanukhina S.G. Rynok intellektual'nogo truda v innovatsionnoi ekonomike Rossii [Intellectual labour market in innovative economy of Russia]. Vestnik Saratovskogo gosudarstvennogo tekhnicheskogo universiteta [Vestnik of Saratov State Technical University]. 2010, vol.4, no.1, pp. 207-217. (In Russ., abstr. in Engl.)
11. Demeshko L.V. Proforientatsionnaya rabota na urokakh tekhnologii kak sredstvo sotsializatsii uchashchikhsya [Career guidance in "handicraft" classes as a means of social adaptation of children]. Aktual'nye voprosy razvitiya obrazovatel'noi oblasti «Tekhnologiya» [Actual issues of subject area "Handicraft" development]. 2013, no.1, pp. 67-71. (In Russ., abstr. in Engl.)

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Pre-University Engineering Training for Children

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The paper considers engineering training provided for children in terms of its objectives, content, methods, and ways of implementation.

Key words: engineering education, additional education of children, organization of training.

Recently, the interest in children's engineering additional education has significantly increased. To develop children's engineering abilities and bring up engineers and scientists of the new generation, innovative models of children's additional education are widely introduced. Among them: joining of Russia WorldSkills International and organizing centers for skill and competency development SkillsCenter, participating in international competitions World Robot Olympiad and RoboTraffic, arranging children's technology parks "Quantorium", etc. One can conclude that additional education is taking a new turn in developing children's engineering and technical creativity.

The goal of our research is to determine the prerequisites of new stage in children's engineering-technological creative development, as well as to describe the trends in children's general engineering training and training of future engineers as a part of additional education.

The system of extracurricular training and education of various artistic profiles including engineering ones was intensively developed during the Soviet era. A wide network of young technicians' clubs, technical art centers, local clubs, technical unions were organized. In N.N. Yartsev's opinion (dissertation of 2006), the system of children's engineering art has gone through the following stages: 1 stage: (up to 1918) – syncretism; 2 stage: (1918-1939) – development; 3 stage: (1940-1960) – maturity; 4 stage: (1961-1986) – boom; 5 stage (1987-1992) – crisis; 6 stage: (1993 – present) – transformation [1].

From the standpoint of content, the transformation stage of children's additional engineering education is conditioned by intensive development of new technologies. Thus, in January 2016, Klaus Schwab, the Presidents of the World Economic Forum in Davos, made a report about the fourth industrial revolution that had emerged and developed since the middle of the last century. Its peculiarity is a fusion of technologies dissolving the initial boundaries between material, digital, and biological worlds. The first industrial revolution was based on using water and steam power to save labour and develop industry, while the second one used electricity to increase the scale and development of mass production, the third one rested on electronics and information technologies for production automation, while the fourth industrial revolution is aimed at development of cyber-physical systems based on big data technology, Internet of things, virtual and augmented realities, 3D-print, printed electronics. In scholars' and practitioners' opinion, the latter will lead to enormous changes of economy and industry in the near term. The new economy needs staff with not only new engineering but also relevant communicative skills – users and creators. It is due to this fact that engineering education development in Russia is now a strategic objective for Russian economic safety and development of human capital.

Engineering education originates in the childhood when acquiring natural-science and engineering knowledge is of particular significance from the standpoint of children's age and psychological peculiarities. At the school age, children learn properties of items, study and construct mechanisms with great interest. At primary school children's visual and logic thinking is intensively developed. At the middle school, more attention is paid to learning natural science and physics-mathematical subjects.

Goals and objectives of engineering education are defined in the National Doctrine of Advanced Engineering Education. On the one hand, it is mass training of children and youth in using innovative and modified devices and technologies in life and job, on the other hand, extraordinary professional competencies of those capable of generating engineering ideas, taking engineering decisions, developing, producing, and maintaining the competitive engineering constructions. Whereas the solution of the first problem aims at increasing the level of engineering culture of the society, the second one is focused on formation of science and technology elite for new industrialization of the country and reinforcing the role of Russian engineers on the world market [3].

Within the period of per-university education children are involved in engineering design through additional education that includes clubs, centers, unions, research labs, technology parks, design bureaus, research teams, events held in technology and engineering sphere functioning on the basis of general educational, secondary professional education institutions and universities, as well as additional educational institutions.

The advantage of children's additional education is implementation of flexible educational programmes that allow for maximal support to and development of children's interest in new knowledge and activities in the sphere of technology and engineering. Children get an opportunity to acquire positive social and personal experience. In the condition of children's education one can identify the two main tasks of engineering education:

1) To increase the level of children's general engineering culture.

2) To reveal and support children talented in the engineering sphere.

Based on these tasks, the model of children's additional engineering education may consist of two concepts: general engineering training and future engineers' training.

From the standpoint of content, children's general engineering training includes such profiles as:

- transport: surface and underground (railway and road), water and underwater, air (aerostatic, aerodynamic, airplanes, helicopters), space;
- building and road building machinery: digging machine with steam engine, excavators, caterpillar machines, carrying and lifting equipment, mixing facilities cranes, elevators, piling hammers;
- military machinery: infantry and fire weapon, battleships, tanks and armored cars, naval engineering, military aircrafts, etc;
- equipment used in everyday life: stove, refrigerator, washing machine, iron, coffee maker, steam cooker etc;
- communication technology: telegraph, telephone, radio station and radio receiver, phonograph, gramophone, telecommunication etc.;
- technical development at different historical periods.

The content of these topics is briefly reviewed, the main operation principles are considered, the models are designed and tested. Both traditional construction sets and robotic, electronic, radio electronic, printing 3D technologies can be used for modeling.

The plan of lessons should give more possibilities for children to creatively develop their activity of learning new laws, concepts, categories, and phenomena. This can be provided by prevalence of problem-research and artistic methods over reproductive ones.

The reproductive methods in engineering education suggest:

- delivery of knowledge;
- assembly of engineering models from ready details using samples, pictures, descriptions, or instructions;
- making experiments and model observation.

The problem-research methods focus a teacher on:

- creation of problem training situation;
- pupils' stating the experimental problems;
- team discussion of possible approaches to an engineering problem solution;
- introduction of changes in a scheme or model construction.

The artistic methods are aimed at arrangements of:

- pupils' individual artistic ideas on developing projects of engineering objects;
- intensive search for the ways of solving inventive and artistic problems.

The general engineering lessons are delivered both in the classrooms and outside the classrooms. At home or in the street, pupils watch the operation of domestic, building, and road machinery, then construct and design automated and robotic models. Children participate in the events aimed at promotion and development of children's engineering art: days of science, festivals, exhibitions, competitions, workshops, etc. The main purpose of these events is not only competitive, but also motivating.

Children learning this field cannot choose engineering job in future, but they will become more sensitive and prepared for using engineering and technological innovations in everyday life and at work place. General engineering classes become a place where children show their inclination to engineering art, develop their engineering thinking, get interested in future engineering job.

The second part of engineering education model in the condition of additional education can be referred to as "Future engineers' training". In this case engineering education involves specialized work with children showing engineering creativity, as it is through the abilities' development that a person reaches the high level in professional and individual growth.

The content of future engineers' training is defined by the following trends:

- impact of scientific discoveries and practical artistic thought (designers, technicians, inventors) on engineering development;
- production (industrial) machinery: mineral extraction and processing (mining, organic synthesis), processing (metallurgy), material treatment (mechanical, chemical), other industries (machine-building, communication, electronics);
- power machinery: thermal power (thermal plants), electrical power plants (energy transition and production);
- reduction of adverse effect of engineering progress: water pollution, soil and air pollution, its impact on flora and fauna, crucial disturbances in the planet ecosystem.

When studying these trends, it is necessary to connect research with physics sections (mechanics, bases of kinematics, bases of dynamics; bases of electrodynamics and electrostatics, etc.), informatics (programming, simulation, and social information).

At the lessons, the most significant thing is artistic activity that makes children think. It is always connected with creation of something new, discovery of new thing, and new abilities in oneself. Besides, artistic activity strengthens positive self-assessment, increases ambitions, and results in self-confident and satisfaction with the achieved results. The role of adults is also very important. They become helpers, organizers, and tutors providing assistance in cognitive activity that enables to turn a pupil from an object to a subject, transit to self- and mutual education and self-development. Parents, teachers and tutors of additional education can and should help a child to reveal his/her creative potential, show his/her best qualities, and maximally realize potentialities.

An important stimulus for engineering art at a higher level is children's training and participation in competitions, Olympiads, contests of different levels: from local educational to All-Russian and international events. There are competitive and artistic constituents in such events. The artistic constituent implies initial setting the problem and evaluation criteria. Based on the problem the participators develop an idea independently, define the goals and objectives of their project, and suggest the ways of problem solution. Within the competitive constituent the problem is defined by the organizers, whereas participators should find the most efficient way of its solution.

The examples of locally-distributed engineering events are as follows:

- Russian research social programme for youth and pupils "Step into Future" (www.step-into-the-future.ru);
- All-Russian Robotic Festival "Robofest" (www.russianrobofest.ru);
- All-Russian Robotic Olympiade http://robolymp.ru;
- All-Russian competitions IKaR and IKaRenok (Engineering staff of Russia) www.ikar.fgos.rf, etc.

One more trend of future engineers' training is cooperation with industrial enterprises, which can be arrange via excursions to enterprises, supervision of children at their project work, delivery of classes and workshops by enterprise experts. Children can observe both operation of definite machines and mechanisms and the entire production at the excursion. An insight in the real production process guides the pupils towards engineering profession.

An important area of work with future engineers is professional guidance of senior schoolchildren assisting to choose engineering profiles at educational institutions of secondary and higher education. This area implies professional guidance meeting with authorities, teachers, students, graduates of these institutions as well as workshops, competitions, and festivals (table 1).

Hence, future engineers' training over the pre-university period has content and methodical potentials in the condition of children's additional education. Nevertheless, resource base and teaching staff for classes of engineering art require to be supported by government, business, and society.

Table 1. Models of children's additional education

Children's additional engineering education		
Trends	General engineering training	Future engineers' training
Target audience	Users	Creators
Key objective	To increase children's level of general engineering culture	To revealing and support children gifted in engineering
Content	Engineering development in different historical periods. Transport, building, road building machinery, domestic equipment, telecommunication etc.	Effect of scientific discoveries on engineering development, reduction of adverse effect of engineering progress. Production (industrial) facilities, power engineering
Methods	Prevalence of problem-research and artistic methods over reproductive ones	Artistic method
Events	Motivation for learning – days of science, festivals, exhibitions, competitions, workshops etc.	Showing achievements – competitions, Olympiads, contests of different level

REFERENCES

1. Yartsev N.N. Stanovlenie i razvitie sistemy detskogo tekhnicheskogo tvorchestva v usloviyakh dopolnitel'nogo obrazovaniya (na primere Samarskoi oblasti): diss. … cand. ped. Nauk [Emergence and development of children's engineering art system in the condition of additional education (by the example of Samara Oblast). Ph.D (Pedagogy) Thesis]. Ulyanovsk, 2006. – 297 p.
2. Evans D. Internet veshchei. Kak izmenitsya vsya nasha zhizn' na ocherednom vitke razvitiya Vsemirnoi seti [Elektronnyi resurs] [Internet things. How our life changes at the turn of Global network development]: Gruppa razrabotki internet-reshenii Cisco dlya biznesa (IBSG). [Cisco IBSG, cop. 2011.]. 14 p. URL: http://www.cisco.com/c/dam/global/ru_ru/assets/executives/pdf/internet_of_things_iot_ibsg_0411final.pdf. Accessed: 06.01.2017.
3. Pokholkov Yu. P. Natsional'naya doktrina operezhayushchego inzhenernogo obrazovaniya Rossii v usloviyakh novoi industrializatsii: podkhody k formirovaniyu, tsel', printsipy [National Doctrine of Advanced Engineering Education in Russia in the condition of new industrialization: approaches to formation, goals and principles]. Inzhenernoe obrazovanie [Engineering education]. 2012. № 10. – pp. 50–65.

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Foreign Language for Engineering Students (Aircraft and Helicopter Industry): Systemizing Training Content

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This paper deals with particularities of content of foreign language training provided to aircraft and helicopter engineering students. The educational information input is suggested to be systematized with regard to learning stages. The authors consider types of linguistic skills and relevant training methods aimed at effective acquisition of the input information.

Key words: foreign language training, foreign language competency in profession-oriented communication, content, input information, types of linguistic skills, training methods.

International contacts and two-level system of higher education implemented in Russia stipulated new requirements to the quality of foreign language training provided to engineering students.

Introduction of competency-based approach resulted in new standards of higher education, and today the content of foreign language training, which is provided to aircraft and helicopter engineering students, should be revised and updated. The present paper deals with training content and systematization of the input information, in particular.

Training content is the bulk of knowledge, skills, and activities ensuring effective individual performance in different spheres of life [1, p. 77].

Therefore, the content of foreign language training is *the content of the educational information input*, and this information acquired, one develops profession-oriented foreign language communicative competency (POFLCC). On the other hand, the training content is communicative abilities and skills, which, taken together, characterize the level of the competency development.

In terms of pedagogical theory, the input foreign language information is systematized and updated to meet the Federal State Educational Standards of Higher Professional Education (FSES HPE) [2]; on the basis of exemplary programme "Foreign Language for Students from Non-Technical Majors" [3]; "Foreign Language" syllabus designed for Aircraft and Helicopter Engineering Students (160100.85) [4]; "Aircraft and Helicopter Engineering (24.05.07)" curriculum [5].

The exemplary programme dated 2009 is used due to the fact that it was designed within competency-based approach and is focused on developing foreign language communicative competency. As for FSES HPE and the curriculum, they were passed in 2010 and 2011, respectively.

According to the curriculum, the discipline "Foreign Language" focuses on developing general cultural competency OK-5, which means "an ability to write and revise profession-oriented texts, an ability to use a foreign language for business communication" [5].

Developing OK-5, and its foreign language component (POFLCC), in particular, is only possible if the training content is composed in the context of integrative and communicative approaches with traditional and particular educational principles applied (significance for and orientation to future profession, interdisciplinary connections).

The integrative approach to foreign language training conforms to the educational technique with the focus on the content, i.e. content-based language instruction (D.M. Brinton, M.A. Snow, M.B. Weshe, J.W. Oller et al.). Considering this technique, N.L. Uvarova suggests using the term "content-learning", since the meaning is "learning based on the subject content" and the term itself reflects the concept of integration. "Content-learning" means a foreign language and a particular subject being taught simultaneously, as well as the goals of teaching both subjects being integrated [6, p. 215-222].

As a result of investigations in methodology of teaching foreign language, scholars agreed that one of the strongest motivations to learning foreign language is future profession (I.V. Petrivnyaya, N.L. Uvarova, L.P. Klobukova, E.P. Komarova, Zh.V. Perepelkina, Z.I. Konnova, V.F. Aitov, O.G. Krasikova, Yu.N. Karpova, L.P. Kistanova, M.V. Daricheva, O.A. Mineeva et al.).

Thus, O.A. Mineeva, taking into consideration students' ideas and suggestions on the educational course content, came to the conclusion that "...education within supplementary training should be focused on future profession and the knowledge should be acquired to resolve professional tasks" [7, p. 99].

The communicative approach implies that the communicative function is an essential function of language, which is used as a tool for human activities.

M.V. Daricheva pointed out that foreign language training provided to design students should be based on communication, and the goal of training is development of communicative skills to ensure effective profession-oriented communication in foreign language. M.V. Daricheva noted that the key aspect of foreign language training is communicative situation or topic, both of which should be profession-oriented. These model situations are profession-oriented and of communicative nature, therefore, they are called *profession-oriented communicative situations* [8, p. 66].

Alteration of some *aspects* within communicative approach, as well as syllabus analysis and testing, led to the changes in the *syllabus content*.

New syllabi "3+" contain the goals of foreign language training provided to Bachelor's degree students. However, particularities of aircraft and helicopter engineering students (the absence of Master's degree, a doubled number of academic hours – 576 hours in comparison with 288 hours of Bachelor's degree programme) necessitates considering specific aspects of foreign language training provided for Master's degree students. Let us enumerate the specific aspects formulated and detailed by E.N. Baranova when developing the foreign language syllabus for Master's degree programme. According to the author, graduates with Master's degree should know:

- linguistic units, which are most frequently used within a particular professional profile (terms and nomenclature of profession-oriented texts);
- phenomena significant for a particular professional profile and characteristic for social and cultural, scientific and industrial spheres of the countries where the learned language is official;
- standards of linguistic behavior and cultural particularities typical for native speakers in social and cultural, scientific and industrial spheres [9, p. 189].

Let us turn to the principles of selecting and systematizing input information at the first and second educational stages (I, II semesters) within Aircraft and Helicopter Engineering programme. This course is remedial and focuses on revising and acquiring profound knowledge about social, cultural, and academic communication, as well as revising and systematizing grammar.

Therefore, in terms of pedagogy, in the first semester, it is essential for the syllabus to include information on student's communication and lifestyle, university education, native town, life in megapolis, and environmental issues.

In the second semester, students are supposed to get acquainted with the information about the country where the language is naturally spoken, with a particular emphasis on the education system.

However, we suppose that the *emphasis* on the education system is more suitable for the syllabus designed within programmes in Pedagogy.

Taking into account the FSES HPE and the goals of Aircraft and Helicopter Engineering programme, we suggest adding social and cultural topics. For instance, the engineer, when on a business trip, can face different everyday life situations, so, studying such topics as "In the Airport", "Hotel", "In a Cafe" will allow the engineer to quickly adapt in an overseas environment and successfully perform his/her professional activities. It is noteworthy that developing communicative skills in the context of the above-mentioned situations is based on ***the principle*** *of using professionally significant information.*

Another particularity of educational information input is introducing topics on future profession and modern trends in technological development based on ***the principle*** *of using profession-oriented and understandable information.*

It is clear that social, cultural and everyday life information content focusses on immediate and non-formal communication. While learning, communicative skills are developed in the forms of monologues, dialogues, and short reports, which can be performed within creative and interactive tasks (roleplay, mini-presentation, discussion).

Oral speech, which is naturally used in the social and cultural context of everyday life, as a language skill is developed on the basis of receptive skills and relevant activities – reading and writing based on a model text. Therefore, speaking can be regarded as an outcome since it indicates the acquisition of information within the scope of a particular social and cultural topic. However, elements of speaking are certainly trained when dealing with texts, for instance, doing question-answer tasks and discussions based on the social and cultural topic reflected in the text.

Reading and writing based on a model text, as receptive language skills, are in the focus of foreign language training since the more a student reads and writes, the better he/she speaks.

Reading is both method and tool in foreign language training. Different ways of reading (skimming, scanning, intensive), which serve different purposes: for instance, to get acquainted or to drill various language phenomena (foreign thesaurus, grammar forms, etc.), estimate the level of students' acquisition.

Writing based on a model is quite helpful for reading and preparing monologues. Such writing can be based on one or several texts and implies substituting some text paragraphs by particular information, for instance, that connected with student's lifestyle. Preparing short reports in area studies (for example, a topic on Great Britain) implies identifying key information in the relevant text and compiling it in the form of a summary.

Reading and "model" writing tasks are used to ensure acquiring foreign thesaurus, monitor understanding and information processing within the scope of a particular topic.

Writing as a productive language skill is connected with such tasks as filling in templates (CV, template letter "My University"), writing personal e-mail letters, preparing project tasks (mini-presentation about the city or the country whether the foreign language is spoken).

Table 1 shows particularities of information input at the early stages of university education.

Table 1. Systematization of input information at 1-2 stages of foreign language training

Stage	Communication sphere	Topics (situations)	number of hours
semester 1	Social and Cultural	1. Student and Student's Lifestyle	36
		2. City, Megapolis, Environment	
	Academic	Higher Educatio in the RF, NNSTU n.a. R.E. Alekseev	
	Grammar	Prepositions. Auxiliary verbs, present tenses	36
semester 2	Social and Cultural	1. Country Where the Language Is Spoken: Industry, Political System, Traditions and Culture	20
		2. Business Trip: in the airport, in the airport, in a cafe	18
	Professional	Profession of Engineer. Current Trends in Technology Development	12
	Grammar	Tenses, Modal Verbs	18

Let us systemize the input information at the third and forth stages (semesters 3 and 4), when foreign language training is profession-oriented.

In accordance with the exemplary programme "Foreign Language for Students for Students from Non-Technical Majors", the content should comprise information on future profession, famous scientists and outstanding personalities in aircraft and aviation [3]. However, this *programme* is examplary and only provides recommendations on how to structure the educational content for Bachelor's degree students. This means that there can be some amendments proposed by the teachers involved in foreign language training.

In terms of profession-oriented foreign language training, it is reasonable to use the integrative approach with an emphasis on acquisition *of professionally significant knowledge of foreign language*, in particular, learning terminology and developing skills of information search, interpretation, and processing within the scope of a certain professional profile.

It seems to be well-grounded to provide information on famous scientists and outstanding personalities in aircraft and aviation through reading for gist (skimmimg).

The key **principle** to select and systemize information at the current stage is using *interdisciplinary connections* between foreign language and professional disciplines ("Aircraft (Helicopter) Construction", "Mechanical Equipment Systems", "Aircraft Flight Dynamics", "Aircraft Armament Systems", etc.).

It is worth noting that the suggested model of content-learning can be correlated with a type of "topic-based teaching" [10]. This model works for any non-linguistic programme since the topics can be selected to meet the interests and needs of students of any professional profile.

The content of profession-oriented foreign language training does not revise, but deepens and updates the content of the relevant professional discipline, broadens the mind and professional worldview of future aircraft engineers.

Profession-oriented foreign language texts are difficult enough to comprehend, contain a lot of complex syntactic constructions, terms, and professionalisms. The main goals of working with such texts are exploratory reading and writing, in particular, identifying and presenting the key information (summary, abstract, plan, key words). Such work is particularly fruitful when preparing mini-presentation and reports. It is clear that oral speech is challengeable for students; therefore, to ensure professional communication in classroom, it is better to select the most significant information, which can be reproduced in the talk and built up without text.

The topics of the professional section are given in table 2.

The requirements that specialist's degree graduates should meet imply introduction of ***"business section"***.

In accordance with the FSES HPE, the graduate should be able to apply foreign language knowledge in correspondence, negotiations, preparing business documents, as well as possess well-developed communicative skills to discuss professional issues in foreign language [2, p. 14-15].

According to the exemplary "Foreign language" programme, business section, which comprises several modules ("Company Presentation", "Business Trip to Foreign Country", "Business Correspondence"), is introduced in the third semester. However, to ensure profession-oriented learning and efficient monitoring, it is more reasonable to distribute the topics of the business section over the two semesters (3 and 4), with 72 and 68 hours, respectively.

Thus, in the third semester the teacher should provide relevant information on the topic "Company", which includes such aspects as company structure, world-know companies and the history of their development, the leading aircraft company in the city.

In the forth semester students should practice business communication, simulating negotiations on new equipment and including such points as price, discount, terms and conditions of delivery and payment. It is worth noting that this content is understandable and useful not only for future engineers, but for Bachelors of any professional profile.

Table 2 shows the topics within the business section.

Business communication skills are developed through all four types of activities: reading, writing, listening, and speaking. Business communication is simulated by means of short reports, roleplays, and business games. For instance, the business game "Post-Appointment" implies the analysis of CVs, which can be used as templates for student's CV.

Writing based on a model text is connected with identifying key information (company structure), playing out particular situations, and participation in a roleplay. Productive writing implies writing personal CV, cover letter, and business letter containing information on the leading local aircraft company (the topic "Company").

To sum up, the content of foreign language training is selected and systematized relying on the principles as follows: *consistency, succession, continuity, orientation to future profession, ease of understanding, interdisciplinary connections, and cross-subject links.*

Theoretical and practical value of the present paper comes from updating and systematizing the input information used for foreign language training in the context of traditional and specific principles; the case-study materials can be used for teaching Aircraft and Helicopter Engineering students in any higher technical school.

Table 2. Systematization of content at 3-4 stages of foreign language training

Stage	Communication sphere	Topics (situations)	number of hours
semester 3	Professional	Profession-oriented information (classification of aircrafts); aircraft construction; helicopter; famous scientists and outstanding personalities in aircraft and aviation	42
	Professional and Business	Company: company structure, world-know companies and the history of their development, the leading local aircraft company (letter to a potential business partner)	12
	Systematizing Grammar	Complex grammatical structures, sequence of tenses	18
semester 4	Professional	Profession-oriented information: flight velocity and altitude, aircraft flight dynamics (jet aircraft); aircraft flight control systems	56
	Professional and Business	Negotiations on buying new equipment	12

REFERENCES

1. Markova S.M. Pedagogicheskoe proektirovanie v usloviyakh nepreryvnogo mnogourovnevogo professional'nogo obrazovaniya [Course and curriculum design within continuing multi-stage system of professional education]. N. Novgorod: VGIPI, 1999, – 88 p.
2. Ob utverzhdenii i vvedenii v deistvie Federal'nogo gosudarstvennogo obrazovatel'nogo standarta vysshego professional'nogo obrazovaniya po napravleniyu podgotovki (spetsial'nosti) 160100 Samoleto- i vertoletostroenie (kvalifikatsiya (stepen') "spetsialist" [Elektronnyi resurs]: prikaz Min-va obrazovaniya i nauki Ros. Federatsii ot 24 dek. 2010 g. № 2054. [Passage and implementation of the federal state educational standards of higher professional education for professional profile 160100 Aircraft and Helicopter Engineering, Specialist's degree programme: the order passed by the Ministry of Education and Science of the Russian Federation dated December 24, 2010 № 2054]. Accessed in information and reference system "Kodeks".

3. Ter-Minasova S.G. (ed.) "Inostrannyi yazyk" dlya neyazykovykh vuzov i fakul'tetov [Elektronnyi resurs]: primer. progr. ["Foreign Language" programme for students from non-technical majors: exemplary programme]. Moscow, 2009, – 23 p. URL: http://www.vgsa.ru/facult/eco/kaf_cgd/doc/language_pr1.pdf (Accessed 17.12.2016).
4. Baranova E.N., Lazarevich S.V., Gnenik M.E., et al. Rabochaya programma distsipliny "Inostrannyi yazyk" po spetsial'nosti "Samoleto- i vertoletostroenie" 160100.85. ["Foreign Language" syllabus designed for Aircraft and Helicopter Engineering Students (160100.85)]. Registered in Education Directorate, registration number 1601001–13, dated 10.03.2012. N.Novgorod: NNSTU, 2012, – 42 p.
5. Rabochii uchebnyi plan podgotovki diplomirovannogo spetsialista. Napravlenie podgotovki (spetsial'nosti) 24.05.07 «Samoleto- i vertoletostroenie». Spetsializatsiya «Samoletostroenie». Ochnaya forma obucheniya [Elektronnyi resurs]: odobren UMS vuza 19.09.2011, protokol № 1. [Curriculum for Specialist's degree programme. Professional profile 24.05.07 "Aircraft and Helicopter Engineering". Specialty – "Aircraft Engineering". Intramural form of study: Affirmed by Uniersity Education Board 19.09.2011, record № 1]. N. Novgorod: NNSTU. 13 p. URL: http://www.nntu.ru/sites/default/files//file/svedeniya-ob-ngtu/its/obrazovanie/och/spec/24.05.07-sivs/ss/Ucheb_plan_24.05.07sivs_ss_19.09.11.pdf, (Accessed 17.12.2016).
6. Uvarova N.L. Gumanitarizatsiya professional'nogo obrazovaniya gosudarstvennykh sluzhashchikh sredstvami lingvisticheskoi podgotovki. Dis. d-ra ped. nauk. [Humanization of professional education of government officials through language training. Dr. Sci. (Pedagody) diss.]. Kazan, 1999, – 402 p.
7. Mineeva O.A., Krasikova O.G. Formirovanie professional'no-inoyazychnoi kommunikativnoi kompetentnosti budushchikh inzhenerov v vuze. [Developing profession-oriented foreign language competency of engineering students at university]. N. Novgorod, 2011, – 196 p.
8. Daricheva M.V., Krasikova O.G. Obuchenie professional'no-inoyazychnomu obshcheniyu budushchikh spetsialistov v oblasti dizaina [Foreign language communication training provided for design students]. N. Novgorod: VGIPU, 2009, – 179 p.
9. Baranova E.N., Pankratova E.N. Modifikatsiya tselei i soderzhaniya inoyazychnogo obrazovaniya v magistrature tekhnicheskogo universiteta. [Revision of goals and content of foreign language syllabus within Master's degree programmes at higher technical school]. Innovatsionnye tekhnologii v obrazovatel'noi deyatel'nosti: sb. tr. Vseros. nauch.-metod. konf. (N. Novgorod, 3 fevr. 2016 g.) [Innovative technologies in education: Proceedings of the national scientific and methodological conference (N. Novgorod, February 3, 2016)]. N. Novgorod: Publ. NSTU, 2016, – pp. 186–192.
10. Brinton D.M., Snow M.A., Wesche M.B. Student-based second language instruction. Newbury: Newbury House Publishers, 1989, – 10 p.

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Quality Management Competency as an Essential Component of Professional Qualification of Engineering Graduates

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The authors focus on developing quality management competencies conducting the case study of education programme "Materials Science and Technology of Materials". The authors consider the skills of quality management to be crucial for today's engineering graduates and suggest enhancing Bachelor and Master of Engineering curricula with practice-oriented disciplines, modules, and practices, with relevant examples given.

Key words: quality of education, engineering education, quality management, competency development, curriculum design, engineering education programmes.

In the past decades the issues of engineering education have been actively discussed. Among these issues methods and tools of its quality enhancement as well as ways of their implementation into university functioning are particularly debated. It is commonly agreed not only in Russia, but also in the world that development of only special professional competencies does not meet employers' requirements for engineering graduates. In our opinion, one of the competencies necessary for a graduate engineer is a competence of quality management. This article considers the question of this competence development using the example of students of "Material Science and Technology of Materials" profile.

In 2011, when universities started students' training including engineering ones, in accordance with the State Federal Educational Standards of Higher Education, the universities and departments gained large discretion in designing both curricula and syllabi of the subjects. In doing so, it was necessary to ensure students' cultural and professional competencies. This trend is supported by the educational standards of the latest generation FSES 3+. As a rule, the design of curricula (i.e. inclusion of subjects in curriculum, their content and volume, a set of competences produced by each definite subject) is performed by graduate departments of university. Leaving some subjects beyond the curriculum and transfer to the competence-oriented education, on the one hand, facilitated the work of graduate department, on the other hand – complicated. Historically, the graduate departments are mainly focused on inclusion of mostly field-specific subjects in the curriculum when developing engineering curricula, as they are responsible for training students for their main professional activity (application of knowledge about materials, research methods, testing and diagnostics of materials, products, processes of their production, skills of engineering process modeling, etc.). In addition, some professional competencies are acquired in reduced and generalized form, as a part of more significant, in the graduate department's opinion, subjects. This approach leads to very superficial knowledge of "non-major" subjects and results in problems of engineers' adaptation in the workplace. Therefore, the graduate departments face the daunting task: despite the established tradition, to design curricula and syllabi to acquire the entire set of competences registered in the standard.

At the moment, the issues of quality management are of key importance, as industry, on the one hand, should timely respond to the changes in consumer demand under the condition of continuous reduction in time between innovative development and its implementation and, on the other hand, should manufacture zero-defect products (which is of special importance, for instance, for the space and defense-related spheres) and meet consumer's expectations. Development, implementation, and support of quality management system have become a necessary condition of competitiveness and cooperation with domestic and international partners for many enterprises. Moreover, the international standard ISO/IEC 15288:2002 (and corresponding national standard RF GOST R ISO/MEK 15288-2005) defines the processes of life cycle of any system produced by a man including engineering one only by 40% as those related to engineering activity, the other processes being referred to project and business management (50% of both forms of processes) and contracting (10%) [1, 2]. Hence, the requirements for engineers' relevant skills are sure to result from the standards. It turns out that modern economy needs a graduate who is not just technically competent specialist, but an engineer-manager, and potential research-engineer in future. Based on the mentioned above, the engineering profiles referred by the Education Ministry Order to the priority ones are largely focused on inclusion the issues related to production quality and skills of corresponding document design in the training process.

Most standards of engineering profiles include, in various contexts, the issues of quality (metrological assurance production service, paperwork and participation in quality management system functioning, etc.). Besides, it should be noted that in the third generation education standards great attention is paid to graduate's commitment to participate in certification of processes, engineering tools etc.

Let us consider the former version of the Federal State Education Standard FSES 3+ in detail for the "Materials Science and Technology of Materials" profile. In the education standard of the considered profile, both for Bachelor's and Master's degrees, among the fields of professional activities there is as follows: "processes of producing materials, parts, half-finished parts, details and items, as well as managing their quality in different spheres of engineering and technology". Moreover, as a part of professional activity the standards of both levels (Bachelor and Master) determine "methods and techniques of quality management of materials, films and coverings, half-finished products, parts and tools" and "normative-engineering documentation and certification systems of materials and products, engineering processes of their production and treatment" [3, 4]. Let us turn our attention to some competence constituents which a Bachelor of this profile should have taking into account the type of professional activity at which Bachelor curriculum aims [3]:

a) Research and analytical constituents:

- commitment to apply modeling methods in standardization and certification of materials and processes;
- commitment to make complex research and tests when studying the materials and products including standard and certified ones.

b) Production and project constituents:

- commitment to apply technical means of measurement and control necessary for standardization and certification of materials;
- ability to apply knowledge about technical production preparation, quality, standardization, and certification of products and processes in industry using economical analysis.

c) Management constituents:

- ability to use principles of production and personnel management.

For Masters of the same profile, the following competencies (or their constituents) are detailed [4]:

a) Research and analytical constituents:

- ability to use methods of modeling, optimization, standardization, and certification to assess and predict material properties and efficiency of technological processes.

b) Production and project constituents:

- ability to use standards and instructions of engineering production, quality, standardization, and certification of products and processes in technological processes and operations.

c) Management constituents:

- commitment to implement production quality management system in the sphere of engineering activity.

Thus, there is a clear necessity of due attention to the disciplines training in quality management at the level of education standards. However, along with inclusion of these disciplines into curriculum, it is important as well to consider their content, focus on learning definite application of quality management means and methods as well as examples of quality management system (QMS) implementations.

It should be also noted that FSES competences of "Materials Science and Technology of Materials" profile for Bachelor and Master degrees are focused on different aspects of quality management. For example, future Bachelors are to have the ability defined as "be ready for activity related to production quality management". For future Masters this ability increases up to participation in processes of production quality management of a company. This fact should be taken into account in designing discipline content, particularly that of Master curriculum.

In case of inclusion of the discipline developing quality management competence into the curriculum, it is often tempting to maximally decrease the number of credits or hours and generally outline the principles of quality management, ISO 9000 standards, algorithm of certification for both materials, processes and QMS. Nevertheless, when an engineering graduate starts to work at an enterprise, he/she has to practically acquire quality standards, namely, clearly defined means and methods of control, management, and improvement of production quality. It should also be noted that the priority of a university is to give students a sound academic background, i.e. satisfaction of interested parties with education service. In our opinion, the interests of the parties mentioned could be equally accommodated: students; state or company investing in education; employers hiring the university graduates; parents' committee; university itself; society [5]. Therefore, it is essential not only to comply with the formal requirements of educational standard and "fill in" the curriculum with important, from the graduate faculty's point of view, disciplines, but also take into account the real employers' demands for an engineering graduates' competency.

The educational standards of the latest generation include definite requirements for classes intended for profile training, for example, for engineering profiles the number of lecture hours, as a rule, should not increase 30-50% of other forms of classes. We suggest the general issues of quality management to be studied independently, but the curricula of the corresponding disciplines should be focused on practical application of studied theoretical concepts.

Using an example, let us show possible content of disciplines developing competencies of quality management taking into account specific engineering activity.

As a result of theoretical training, a Bachelor should acquire:

- general knowledge about approaches to quality assurance at an enterprise with due consideration of specificity in different production life cycle stage: management of communication with consumers, design and development, purchase, production, and service;
- the concept of process (including technological and production), essential parts of the process;
- idea of enterprise (company) function in the form of process network (so called process approach);

- information about main tools of quality management;
- knowledge of bases of metrological production assurance;
- awareness of competent standardization and certification of materials and processes.

As for practical training, along with application of described theoretical knowledge in practice, it is not of less importance to acquire skills in production quality management, and, consequently, application of statistical methods to assess production quality, process control, accuracy analysis, manageability and sustainability of the processes (for instance, assessment of checklists and various charts) and methods used on selected production quality management.

In our opinion, according to the competencies, Bachelor or Master of material science also needs, perhaps in the form of internship, to learn a really functioning QMS at a definite company of relevant industry (including the possibility of visiting this company, examining some documentation, participating in workshops held by quality service representatives and students' independent design of some documents). Moreover, at the internship Masters' attention should be focused on studying management and other processes resulting in the increase of production quality.

In our opinion, it is important that having practical skills in quality management, future engineer would quickly adapt to the real production conditions where he/she would be involved in improvement of production, processes etc.

Hence, to meet the requirements of modern industrial society, we believe it is necessary to include practice-oriented disciplines, parts of disciplines and practices in Bachelor's and Master's curricula to endow students with quality management competencies.

Let us consider implementation of the statements mentioned above using the example of Bachelor students training.

It is suggested to separate a section related to development of students' knowledge about production quality management system and skills of implementing this system as a part of internship. In our opinion, it is useful for students to acquire knowledge, including theory, necessary for developing relevant skills and competencies, or its part before the internship. Therefore, firstly, it is appropriate to define one or more disciplines or their units in the curriculum preceding the internship and containing relevant theory (for instance, "Metrology, standardization and certification", "Bases of quality management" etc.). Secondly, before the internship the students have review lectures and their level of theory knowledge in the sphere of quality management is tested. After that, a company with appropriate science and technology structure and using the methods of production quality management (preferably with QMS) is chosen for internship. Thus, thus internship would contribute to acquiring both professional engineering skills (the main part of practice), and skills in quality management of a given industry (the section suggested by us). As a result, students can develop the most complete idea of both local engineering processes, equipment, material properties etc. and global issues of production, functioning and organization with due regard of quality assurance. At the end of internship one can test theory again to define the effect of practical skills on the level of students' training concerning the quality issues.

The key aspect related to the quality of production is documents of engineering processes. Therefore, we suggest students' mastering knowledge on process engineering and quality as a part of profile discipline related to the study of engineering material and structures. In this case the skilled mentioned above are suggested to be acquired at seminars or laboratory works. For example, one of the laboratory works (or one of practical tasks at seminar) can partially or completely include description of the GOST format for engineering documents. Thus, on the one hand, the list of questions on the given theme is given to the students to study independently. It includes the relative normative documentation, which allows the lectures to be delivered on the basic professional issues. On the other hand, engineering documents are mastered by the students at one of classes, which allows a teacher to check their independent work and a student to monitor and test their skills in real production condition.

Hence, we have grounded the necessity to include practice-oriented disciplines (or their sections) and internship enabling development of quality management competence into the curriculum of Bachelors and Masters as well as identified the potential ways of achieving this goal.

It should also be noted that the research problem implies further development of necessary educational technologies and methods that, on the one hand, make information easier for the students and, on the other hand, develop students' quality management competence.

REFERENCES

1. ISO/IEC 15288:2002. Systems engineering – System life cycle processes / ISO/IEC/JTC 1/SC 7. Geneva: ISO/IEC, 2002. – 90 p.
2. GOST R ISO/MEK 15288-2005. Informatsionnaya tekhnologiya. Sistemnaya inzheneriya. Protsessy zhiznennogo tsikla sistem. [GOST R ISO/MEK 15288-2005. Information technology. System engineering. Processes of system life cycle] Moscow: Standartinform, 2006. – 57 p.
3. FGOS VO po napravleniyu podgotovki 22.03.01 "Materialovedenie i tekhnologii materialov" (uroven' bakalavriata) [Elektronnyi resurs]: utv. prikazom Min-va obrazovaniya i nauki Ros. Federatsii ot 12 noyab. 2015. № 1331. [HE FSES in the profile 22.03.01 'Material Science and Material Technologies' (Bachelor degree)]. fgosvo.ru: portal Federal'nykh gosudarstvennykh obrazovatel'nykh standartov vysshego obrazovaniya. Moscow, 2017 fgosvo.ru. – 22 p. URL: http://fgosvo.ru/uploadfiles/fgosvob/220301.pdf, (Accessed: 29.12.2016).
4. FGOS VO po napravleniyu podgotovki 22.04.01 "Materialovedenie i tekhnologii materialov" (uroven' magistratury) [Elektronnyi resurs]: utv. prikazom Min-va obrazovaniya i nauki Ros. Federatsii ot 28 avg. 2015. [HE FSES in the profile 22.03.01 'Material Science and Material Technologies' (Master degree)] № 907. fgosvo.ru: portal Federal'nykh gosudarstvennykh obrazovatel'nykh standartov vysshego obrazovaniya. Moscow, 2017 fgosvo.ru. – 24 p. URL: http://fgosvo.ru/uploadfiles/fgosvom/220401.pdf, (Accessed: 29.12.2016).
5. Venig S.B., Vinokurova S.A. Analiz trebovanii zainteresovannykh v obrazovanii storon dlya obespecheniya ego kachestva [Analysis of requirements of education stakeholders to ensure its quality]. Vektor nauki TGU [Vector of TSU Science]. 2011. № 4. – pp. 500–502.

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Cluster Approach to Engineering Training for Machine Building Industry in a Single-Industry Town

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The article describes a cluster approach to engineering training for enterprises of a single-industry town; the case study is a branch of the oldest Kazan technical university. The cluster strategy is implemented via integration of educational institutions and industrial enterprises.

Key words: engineering complex, cluster approach, single-industry town, educational cluster, integration, principle of historicism, social partnership.

Modern machine building industry of Russia involves more than twenty branches and sub-branches, with the enterprises being located in different regions of the country. The machine-building complex of the republic of Tatarstan includes large and medium-sized enterprises relating to this industry (machine-building, compressor-building, aircraft construction, shipbuilding, tool production, etc.).

The development of machine building production correlates to the development of vocational and engineering education system in the republic. The history of Zelenodolsk clearly represents this close relation. The foundation and development of such enterprises as the publicly held company (PHC) "Zelenodolsk plant named after A.M. Gorky" and machine building company named after Sergo Ordzhonikidze (POZIS) are closely linked to the history of vocational schools no. 25 and 22, the shipbuilding school (founded in 1944) and the mechanical technical school (established in 1939). These enterprises were also involved in patronage of some secondary schools of the city. POZIS has been mentoring schools no. 4, 14, and 11 for several decades. Schools no. 1, 3, and 9 are under the patronage of "Zelenodolsk plant named after A.M. Gorky".

The analysis of the past reveals the correlation of production and educational processes that are locally restricted by the same area. This functional dependency should be studied in terms of current situation, and can be a base to solve the problem of single-industry towns. The development of single-industry towns, which are economically dependent on one factory or industry, is a challenge of the national level. To deal with it, the Single Industry Town Development Fund (SITD) was established in September, 2015. Two towns from Tatarstan, one being Zelenodolsk, were included in the list of the towns with the most difficult social and economic conditions. Complex approach used to discover new sources for the regional development implies assessing educational, methodical and scientific potential of the local educational institutions.

Historical review allows revealing characteristic features of the relations developed between the enterprises and educational institutions of Zelenodolsk in the distant and recent past, considering their interaction patterns, and understanding the historic conditions that determined the ways of staff training.

The same principle can be applied to understand the current changes taking place in modern system of professional education in Russia. Branches of technical universities are being established in small industrial towns; vocational training schools are being integrated with higher education institutions; the staff training process is being reformed. A new model of interaction between enterprises and educational institutions is historically grounded. The model aims at training staff of new generation, and is based on the idea of the educational cluster. The notion "cluster" is applied in many spheres of human activity and defined by a number of researchers both Russian and international ones (G.B. Kleiner, M.A. Mirganyan, M. Porter, D.Yu. Trushnikov, T.V. Tsikhan, et al.) According to M. Porter: "Clusters are geographic concentrations of interconnected institutions and companies from a certain domain. Clusters consist of a group of related industries and other important entities from a competitiveness point of view. These include, for example, specialized input (such as components, machines and services) suppliers or specialized infrastructure suppliers" [1].

Education clusters started to be established in the 90-s of the 20 century. The law support of the cluster policy at the federal level (the RF Government orders of 2006 and 2008) facilitated the development of cluster development in the education system. T.I. Shamova, who was among the first proving the necessity of the cluster approach in education, underlines its capacity in self- and inter-development of the cluster subjects [2]. A.V. Smirnov distinguishes such characteristic of the education cluster as a set of vocational training institutions that are united by their professional areas, and their partnership with the enterprises [3].

The partner relations between enterprises and training institutions play a special role in the development of both stakeholders. Their proximity ensures fast response on the partner's social needs. Rapid response is of special value for problem solving in such kind of towns. Thus, the development of an industrial and logistic area became one of the ways to modernize Zelenodolsk. This fact conditioned a new education programme to train logisticians.

A government programme for education development contains the idea of the cluster approach to engineering and technical training. It is approved by the document "On the concept of engineering training in Russia" issued by the RF State Duma. According to the document, " it is of special importance for engineering universities to reconstruct such training systems that would ensure regional enterprises' influence on the content and quality of engineering training to provide them in the future with specialists of required competencies and skills" [4]. The education cluster becomes a renovated form of a social partnership that is developed with account of the new requirements to the vocational training system (for example, the employers participate in education programme development to define the competencies to be acquired within the training period; they assess the learning outcomes of the graduates; they take part in certification procedures, etc.).

The Tatarstan government adopted "The concept of education cluster development" (2006) and the programme "Development and distribution of the productive forces based on the cluster approach for the period until 2020 and 2030" (Cabinet of Ministers decision No. 763, dated 22 October 2008), which contributed to the establishment of the education clusters in the Republic, since industrial clusters induced the development of the education clusters focused on training the staff for particular industry needs.

The vocational education clustering is supported by industrial enterprises that promote establishing branches of universities in different towns of Russia. For example, the branch of Kazan National Research Technical University named after A.N. Tupolev (KNRTU-KAI) founded a branch in Zelenodolsk in 2000, which resulted from the staff demand of "POZIS". The company's management established the branch of the higher education institution based on the local vocational technical school, and stayed in close contact with the newly founded institution. In 2008 the branch received the status of institute and has become

Zelenodolsk Institute for Machine-Building and Information Technologies (ZIMBIT), which is KNRTU-KAI's branch.

The clustering process has resulted in diverse models of education clusters. The cluster approach is the base for interaction of vocational educational institutions located in the close proximity of each other (for example, there is a scientific and educational cluster relating to trade, hospitality and service industries; it unites a number of higher schools and schools of vocational training, including Kazan Innovative University named after V.G. Timiryasov (IEML)). The cluster approach is also a base for internal development of most of the universities in Tatarstan. Thus, KNRTU-KAI and its branches is a developed educational net integrated in a united educational environment, with its structural units being vocational institutions, scientific research institutes, and training centers founded in industrial enterprises in Tatarstan. Clustering ensures a vertical educational net with KNRTU-KAI in its center. It provides systematic and continuous training of staff to meet the demand of particular local industrial enterprises. However, the KNRTU-KAI educational cluster is not only the system of vertical links. The development of branches is the development of horizontal relations between the subjects of integration. The members of the horizontal educational net are parties located within the municipal entities of Tatarstan Republic. The integration of their interaction aims at their efficient functioning.

Thus, "Zelenodolsk plant named after A.M. Gorky" used scientific and pedagogical experience of ZIMBIT KNRTU-KAI to train skilled workers, which is a renovation of "vestibule training" model, once had existed. With participation of the branch, the advanced training for the vocational instructors involved in staff training was organized. In its turn, ZIMBIT KNRTU-KAI has a possibility to use the equipment, facilities and specialists of the company for training the students, the future engineering staff of the industry.

Clustering facilitates product promotion in the net. The product of education is graduates; the product of scientific activity is research and development works ("know how") done with the help of the students. A multifunctional lathe machine, a manipulator, developed with participation of ZIMBIT KNRTU-KAI students and faculty, were offered to be introduced in the production in "Zelenodolsk plant named after A.M. Gorky". Close collaboration between the university and the company allows reducing the demand of the local companies for qualified specialist of new formation.

Scenarios for development of educational clusters have much in common; however, they have their particularities that are conditioned by specific features of a local industrial structure. Thus, the foundation of ZIMBIT KNRTU-KAI was actively supported by POZIS. The education programmes were firstly focused on machine building industry. The demand for qualified staff in the ship building industry led to the changes in the structure of ZIMBIT KNRTU-KAI. It integrated with the Shipbuilding technical school, which was supported by the company "Zelenodolsk plant named after A.M. Gorky". This school had provided the company with highly qualified workers for many decades. Its integration in the environment of the higher education institution, with its high scientific and methodological potential, brought positive changes to the training process at the technical school. The integration resulted in development of new training areas and professional profiles of the education programmes implemented by ZIMBIT KNRTU-KAI.

Cluster approach applied in education focused on needs of modern production and contemporary methodological ideas (for example, the idea of continuous training), implies dialectical development of the previous experience and traditions. The companies' patronage of the secondary schools is a valuable experience in continuous engineering training for machine building industry in Zelenodolsk.

A modern form of such patronage of school No. 4, 11, 14 is the foundation of special classes "Engineers of the future", which were initiated by POZIS. The company funded additional training courses in physics and mathematics at school to help the pupils enter technical universities. These classes are held not only by school teachers but also by the faculty of ZIMBIT KNRTU-KAI, which allows enhancing career advice service for potential students and adjusting students to the university requirements more easily.

The cluster approach in engineering training system aims at reducing the disbalance between the employers' expectations from young specialists and the real competency level of the graduates. According to A. Shmarov, A. Adreyenkova, and I. Glinkin, universities often have little understanding of what are the employers' requirements for graduates' mobility, adaptability, and professional self development [5, p. 6]. The vertical and horizontal cluster net of KNRTU-KAI can significantly increase the graduates' mobility, since the production companies are active parties of the net. Within the programme of vocational training students can acquire a working speciality and practice it during their internship.

There are different models of interaction between ZIMBIT KNRTU-KAI and employers. For example, those students who do a special vocational course in "ship building" have internship in the Training center of "Zelenodolsk plant named after A.M. Gorky" starting with the second year of study. During the internship the students visit all the shops and departments of the plant and communicate with the managers. In the third year of study, the students are distributed in different shops and departments with regard to their wishes and interests for further internship and course paper work. This distribution is a career star for most of the students.

The interaction model implemented in collaboration of ZIMBIT KNRTU-KAI and POZIS has the idea of a dual training system. Based on mutually developed training programme, new work places are created for the students to put their theoretical knowledge in practice during the internship.

Another way to train future employees is to attract leading specialists of the companies to the training process. Such interaction is practiced between ZIMBIT KNRTU-KAI and JSC "Zelenodolsk Company "ERA".

Our own experience in implementing the cluster approach proves its high relevance and value in the education system and single-industry town development".

REFERENCES

1. Porter M.E. Mezhdunarodnaya konkurentsiya: Konkurentnye preimushchestva stran [International competitiveness: Competitive advantage of nations]. Moscow: Publ. Mezhdunar. Otnosheniya [International relations], 1993. – 895 p.
2. Shamova T.I. Klasternyi podkhod k razvitiyu obrazovatel'nykh sistem [Cluster approach to the development of education system]. Vzaimodeistvie obrazovatel'nykh uchrezhdenii i institutov sotsiuma v obespechenii effektivnosti, dostupnosti i kachestva obrazovaniya regiona: materialy 10 Mezhdunar. obrazovat. Foruma [Interaction of educational institutions and social institutions to ensure effective, available and well-qualified education in a region: Matherials of the 10th International education forum]. Belgorod, 24–26 October 2006. Belgorod: Publ. BelGU, 2006, vol.1, pp.24–29.
3. Smirnov A.V. Obrazovatel'nye klastery i innovatsionnoe obuchenie v vuze [Educational cluster and innovative training at universities].Kazan': Publ. RITs "Shkola", 2010. – 102 p.
4. O kontseptsii doktriny podgotovki inzhenernykh kadrov v Rossii [Elektronnyi resurs] [On the concept of the doctrine of engineering training in Russia]. Analit. vestn. [Analytical vestnik], 2012. Iss. 5, – 34 p. URL: http://iam.duma.gov.ru/node/8/4921, (Accessed: 09.12.2016).
5. Shmarov A., Adreenkova A., Glinkin I. Vuzy i rabotodateli o vypusknikakh i reforme vysshei shkoly [Universities and employers about graduates of the reform of the higher school]. Moscow: Publ. Rusal, 2005. – 49 p.

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A Practical Example of Professional Standards Integration Into the Educational Process of a National Research University

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The article focuses on the issue of aligning HEI study programmes with the present-day circumstances. A problem of major discrepancy between the higher education standards and the requirements of professional community has been indicated. The article justifies as the problem solution the implementation of additional competences which should guide graduates to carry out work functions introduced by professional standards.

Key words: competences, educational standards, professional standards, learning outcomes.

A shift of priorities in the development of hi-tech and strategically important sectors of Russian economy requires updating of study programmes, majors and specialties in accordance with the approved professional standards. At the same time, representatives of the professional community remark the discrepancy between learning outcomes after graduation and employers' requirements. It is said that over 65% of employers prefer to provide extra training or retrain their workers on the basis of their own educational departments [1, p. 14], which indicates the gap between the contents of educational standards of higher education and the requirements towards learning outcomes demanded by the real economy that are stated in the professional standards. This problem is topical for training engineering workforce.

In order to assure study programmes competitiveness it should indicate such learning outcomes that clearly state knowledge, skills and attitudes demanded by the economic sector of graduate's future employment.

One of the traditional approaches to narrow the gap between HEIs' and employers' view on a future graduate is to introduce industry-based departments. However, this approach only allows partly meeting the demand in specialists even within one enterprise.

As a different solution the Ministry of Education and Science of the Russian Federation proposes to introduce Professional Standards (PS). At the same time aligning the Federal State Educational Standards (FSES) and the Professional Standards leads to new difficulties, first of all, in the organizational process of developing study programmes and designing curricula.

According to the paragraph 11, part 7 of the Federal Law on Education in Russian Federation No. 273-FZ of 29 December 2012 new state educational standards should be formed based on the existing professional standards; thus, the developers of study programmes face the need to take into account the requirements of the PS. However, at the moment, only guidance materials for the designers of educational standards have been developed [2]. With an aim to provide efficient teaching and guiding activities the current study programmes have to be updated in line with the trend of introducing PS into FSES.

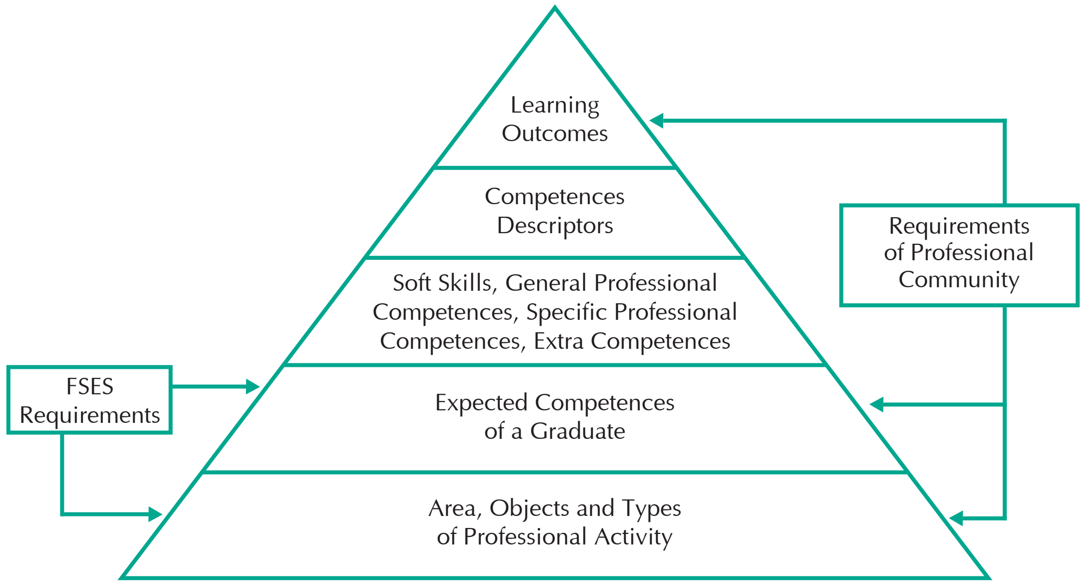
Based on the practice of designing study programmes in National Research University of Electronic Technology the article discloses the opportunity to integrate professional standards into the educational process in cases, when the description of requirements towards learning outcomes stated in FSES does not fully correspond to the requirements set by the professional community. A practical example of this approach is presented further. It has been executed in a study programme on "Informational and communicational technologies and communication systems" of National Research University of Electronic Technology in line with a Plan for Development and Approval of Study Programmes for Higher Education [3].

Development of a study programme begins with designing graduate's competence model, which appears as a comprehensive integral image of the final result of education and is based on the idea of a "competence" [4, p. 8]. Realization of a competence model is aimed at achievement of the expected learning outcomes, which have to correspond to the requirements set for a graduate by professional communities. Authors propose a structure of graduate's competence model that illustrates interaction between professional and educational standards within the study process (fig. 1).

As can be seen from the scheme on fig. 1, study process is focused on learning outcomes, which form knowledge and skills needed for professional activity. The descriptions of Soft Skills, General Professional Competences, and Specific Professional Competences are strictly declared by FSES; however, in order to increase the efficiency of study process authors see the need to provide descriptions of certain sub-competences of the Specific Professional Competences, as well as to introduce Extra Competences using the descriptors of industry's professional standards.

Level of learning outcomes' achievement (i.e. level of competences formation) should correspond to the approved descriptors of competences determined by the Professional Standards. A list of competences of study programmes future graduate, as well as the area, objects and types of graduate's professional activity are determined, on

FIg 1. Approximate structure of graduate's competence model introduced to the study programme on "Informational and communicational technologies and communication systems" of National Research University of Electronic Technology



the one side, by FSES requirements, and on the other side – by the requirements of professional community formulated as work functions and work actions of the corresponding Professional Standards.

As a rule, concordance of FSES and PS terminology is respected as shown in the table 1.

The authors propose an algorithm for integration of professional standards to the educational process for specialty "Informational and communicational technologies and communication systems" of National Research University of Electronic Technology. It should be noted that the proposed approach can be mostly used when executing applied study programmes for training engineers. Though higher education supposes fundamental training and scientific character of the knowledge gained, strict abidance to the requirements of professional standards may lead to the loss of scalability and flexibility in the choice of professional area of a graduate [6, p. 31].

It is proposed to comply with the following order of actions:

1. Types of professional activities for students' acquisition are chosen from corresponding educational standards based on the analysis of labor market demand, scientific and research resources and material and technical facilities of a department.

2. In line with the chosen type (types) of professional activity, professional tasks that graduates should be able to perform are determined.

3. Further, learning outcomes of a study programme are formulated in terms of soft skills, general professional competences and specific professional competences corresponding to the type (types) of professional activity of the SP's focus.

4. If needed, the competences are split into sets of the so-called sub-competences, which present a competence in a form of more particular learning outcomes formulated through sub-competences' descriptors that correspond to the professional standards' descriptions.

5. If the descriptions of learning outcomes corresponding to the chosen type of professional activity do not fully meet the requirements of professional standards, educational institution can supplement the list of learning outcomes by introducing extra competences.

It seems viable, first of all, to formulate more broadly the learning outcomes in the terms of extra competences through work functions determined by a corresponding professional standard, and further to specify them as a set of sub-competences based on the requirements towards work actions.

6. Links between the fostered competences and disciplines or modules are established.

7. In line with the curriculum, work programs of each discipline are developed, as well as means for competences' evaluation.

Table 1. Concordance of the Russian Federation Federal State Educational Standards and Professional Standards terminology [5, p. 3232]

Terminology of PS	Terminology of FSES
Generalized work function	Type of activity
Work function	Professional competence
Work action	Practical expertise
Skill	Skill
Knowledge	Knowledge

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8. The means for evaluation of specific professional and extra competences should undergo expert assessment with participation of representatives from the professional community.

9. In case of positive expert assessment of means for competences' evaluation they can be introduced to the study process.

It should be noted that specific professional competences are described very broadly by FSES. At this, when fostering these competences it is possible to split a particular competence in line with a set of professional tasks that should be carried out by a future graduate. Thus, splitting competences to sub-competences allows specifying a particular competence and creates an opportunity to execute individual learning paths while fostering one or another element of students' competences.

It seems viable to formulate sub-competences and extra competences while focusing on the corresponding work functions from Professional Standards [7, 8] in the field of professional activity that complies with the study major.

The distinction in the approaches to development of PS and FSES lead to the fact that it is not always possible to comply sub-competences and work functions directly. Tables 2 and 3 present the examples of complying work functions and sub-competences/extra competences formed within disciplines of the "Informational and communicational technologies and communication systems" programme.

Feedback from representatives of the professional community on the first stage of the algorithm's introduction is collected during students' industrial internships by gathering and analyzing employers' reviews on students' performance during internships and the results of employers' survey, which reflects level of employers' satisfaction with students' level of professional training.

While the educational standards of the next generation are still in the process of development, higher educational institutions, in particular National Research Universities have the authority [9] to start an active process of integrating professional standards requirements to the educational process. This is essential, first of all, in order for today students of higher professional educational programmes to be demanded on the labor market not only in the near future, but also on a remote prospect.

Table 2. Example of complying work functions with sub-competences

FSES competence	Sub-competence (Discipline)	Work function (Code)
Ability to design project and technical documentation, to draw up final design-and-engineering projects in line with norms and standards (specific professional competence No. 10)	Ability to create technical decisions on a communication object or system (telecommunication system) and its components (Architecture and software for network infocommunicational devices)	Pre-project build-up and development of a systemic project for communication object (system), telecommunication system (A/01.6)
	Ability to design technical documentation using systems of automated design for drawing up documents in accordance with the requirements of Engineering and Computer Graphics	Design of a technical and work project for communication object (system), telecommunication system (A/02.6)

Table 3. Example of complying work functions of PS with extra competences

Work function	Extra competence	Discipline (elective)
Mathematical and computer simulation of radioelectronic devices and systems with an aim to optimize (enhance) their parameters	Ability to design mathematical models of infocommunicational devices and systems and their realization with regard to available elements	Software radio
		Methods of simulation and optimization in infocommunicational systems
	Readiness to use programme software and ability to apply it for creation of new telecommunication systems and nodes	Systems on a chip for telecommunication
		MATLAB mathematical simulation

REFERENCES

1. Strategiya razvitiya systemy podgotovki rabochikh kadrov i formirovaniya prikladnykh kvalifikatsii v Rossiiskoi Federatsii na period do 2020 goda (Strategy for development of workforce training system and formation of applied qualifications in Russian Federation until 2020) [Electronic resource]. – Moscow, 2013. – 58 p. – URL: http://xn--80abucjiibh-v9a.xn--p1ai/media/events/files/41d4701a6bfda8ac356e.pdf, free. – Tit. from the screen (usage date: 12.12.2016).
2. Metodologicheskie rekomendatsii po aktualizatsii deistvuyushchikh federalnyikh gosudarstvennykh obrazovatelnykh standartov vysshego obrazovaniya s uchetom prinimaemykh professionalnykh standartov (Methodological recommendations on actualization of the current federal state educational standards of higher education in line with the incoming professional standards) [Electronic resource]. Approved by the Ministry of Education and Science of the Russian Federation of 22 January 2015 No. DL-2\05vn. – Available from reference legal system "KonsultantPlyus".
3. Poryadok razrabotki i utvergdeniya obrazovatelnoi programmy vysshego obrazovaniya (bakalavriat i magistratura) (Order of Design and Approval of Educational Programmes of Higher Education (Bachelor and Master Degrees) [Electronic resource]. Approved at National Research University of Electronic Technology Academic Board meeting on 15 June 2016 / Ministry of Education and Science of the Russian Federation; National Research University of Electronic Technology. – Moscow, 2016. – 40 p. – URL: https://www.miet.ru/upload/content/Uchebny_process/Poryadok_razrabotki_i_utverjdeniya_OP_VO_(bakalavriat_i_magistratura).pdf, free. – Tit. from the screen (usage date: 12.12.2016).
4. Azarova R.N. Razrabotka pasporta kompetentsii: metodologicheskie rekomendatsii dlya organizatsii proektnykh rabot I professorsko-prepodavatelskogo kollektiva vuzov (Development of Competences Passport: Methodological Recommendations for Organization of Project Work and Faculty of Universities) / R.N. Azarova, N.M. Zolotareva. – Moscow: Research center of problems on quality of specialists training, Coordination Board of Teaching and Methodological Associations and Scientific and Methodological Boards of Higher Schools, 2010. – 52 p.
5. Tarasova T.N. Teoreticheskie aspekty integratsii FGOS i professionalnykh standartov (Theoretical Aspects of FSES and Professional Standards Integration) [Electronic resource] // University complex as regional a center of educational, science and culture: Proceeedings of All-Russian Scientific and Methodological Conference, Orenburg, 3-5 February 206 – Orenburg: Izdatelstvo OGU, 2016. – pp. 3227-3233.
6. Senashenko V.S. O sootnoshenii professionalnykh standartov i FGOS vysshego obrazovaniya (On the Correlation between Professional Standards and Federal Educational Standards of Higher Education) // Vysshee obrazovanie v Rossii [Higher Education in Russia]. 2015. – No. 6. – pp. 31-35.
7. Ob utvergdenii professionalnogo standarta "Ingener-proektirovshchik v oblasti svyazi (telekommunikatsii)" (On Approval of Professional Standard "Design Engineer in the Field of Communications (Telecommunications)") [Electronic resource]: Order of the Ministry of Labour and Social Protection of the Russian Federation No. 316n of 19 May 2014 // GARANT.ru : informational and legal portal. – Moscow: Garant-Service, 2016. – URL: http://base.garant.ru/70697874/#ixzz4LkakqaK1, free. – Tit. from the screen (usage date: 12.12.2016).
8. Ob utvergdenii professionalnogo standarta "Ingener-radioelektronshchik" (On Approval of Professional Standard "Radioelectronics Engineer") [Electronic resource]: Order of the Ministry of Labour and Social Protection of the Russian Federation No. 315n of 19 May 2014. – Available from reference legal system "KonsultantPlyus".
9. Razyasneniya razrabotchikam osnovnykh obrazovatelnykh programme, realizuyushchim federalnye gosudarstvennye obrazovatelnye standarty (Clarification for the Developers of Main Educational Programmes that Execute Federal State Educational Standards) [Electronic resource]: updated on 09 January 2014 // Altai State University: website. – Barnaul, 1999-2016. – URL: http://www.asu.ru/education/struc_edu01/questions/development, free. – Tit. from the screen (usage date: 12.12.2016).

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Modern Models of Training a Professionally-Mobile Specialist

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The main reasons hindering the establishment and development of professional mobility of a future engineer in the socio-cultural educational space of a technical HEI are: the orientation of technical universities to the previously established model of training future engineers and the underdevelopment of the content of future engineers' training. A student has to learn the logic of the development of science, learn how to get knowledge, and get engaged in real professional activities within the learning process of a university.

Key words: professional mobility, continuous education, engineering education model.

The swiftness of transitions that occur in the society "demands" specialists, who are able to analyze changes in country's socio-economic living conditions and to find untypical solutions for industrial problems, which, overall, integrates into the idea of "professional mobility".

The issue of training specialists, who are able to react to the societal changes and can forecast remote shifts in the professional activity, is highly topical for modern professional education.

In the Concept for Long-term Socio-Economic Development of the Russian Federation until 2020 a task is set to foster professional mobility relying on continuous education and professional retraining. This allows workers to increase their own competitiveness on labour market, to realize their work potential in the most dynamically developing sectors of economy [1, p. 57].

The authors agree with the point of view that engineering HEI graduates' competitiveness on labour market and their strength are being currently built upon new "untypical characteristics", rather than just upon their high level of professional training. Such characteristics include possession of extra professional qualities and skills that are not fostered within the basic study programmes, but, at the same time, that encourage amplification and deepening of future specialists' professional opportunities [2].

Besides everything mentioned above, the key trend of innovative training is training elite engineers that have the competence for broad thinking based on a system of meta-knowledge [3].

Engineers with such level of training should be masters of their profession and be familiar with other sciences. They need to have a deep understanding of information technologies and be ready to communicate and cooperate within an international group.

For any engineer it is important to be familiar with any sphere of modern culture, to have high moral standards and to be tolerant, to know well the history of his/her country and the mankind as a whole, to understand human psychology and social processes, etc.

The level of personal skills of an engineering HEI graduate, firstly, has to meet "… the requirements of specialist's adaptation to the modern-day pace of scientific and technological progress and inconstant environment of labour market, and, secondly, (should allow) him/her to harmonize own professional activity with global challenges of civilization, with the issues of preserving and sustaining adequate level of living on Earth" [4, p. 60]. The training should start at school.

In most cases modern pre-university training is focused on "cramming" enrollees on courses that are field-specific for applying to a certain university. Enrollees that choose engineering majors get enrolled based on the results of the Unified State Exams. Career guidance of high school students should develop an informed professional self-awareness and foster the emergence of motivation for studying.

Many prestige world-known educational institutions, such as Oxford, Cambridge, Harvard and other universities seek for enrollees with non-standard and flexible thinking. Enrollees send test results and short bios to the admission offices. Additionally, an interview can be held in order to evaluate the level of enrollee's fundamental knowledge, his/her reaction to unconventional questions, wittiness, personal and psychological qualities, motivation for studying. The closing arguments for the enrollment can be: grades in school diploma, third-party recommendations, extracurricular activities, hobbies and proactive attitude of enrollees [5].

And another example. Students enroll for a number of majors at Tyumen Industrial University based on the results of a creative competition for best inventions. As a rule, this competition coincides with the Day of Russian Science and is held in a form of a scientific and educational marathon. Future enrollees conduct a series of unconventional experiments in HEI's laboratories under the supervision of university teachers. For instance, they diagnose break-gear system determining the toxic level of hazardous substances emissions or design a pipeline. Based on the results of such lab works students are awarded with diplomas of "Inventor – Investigator". Authors of the most interesting ideas receive recommendations for university enrollment. However, even in such a case, the main requirements towards enrollees are still the results of Unified State Exams on physics and math.

At this, it is relevant to address the opinion of a modern philosopher, N. Krylova, who stated that "to focus the training process only on subjects and disciplines is to support Scientists, who considered physics and mathematics as "role-model sciences" and encouraged to build other sciences upon those, whereas culture inherits polysystemic ways of action [6, p. 21]. Fallacy of the Scientists' (from lat. scientia – science) concept is triggered by the fact that scientific and technological progress cannot automatically lead to dissolution of all complex problems and sharp contradictions of social life.

The existing unsound practice of Russian university enrollment by results of the Unified State Exams puts enrollees' emphasis on entering any budget-funded major outside of their interests and desires. It turns to be a deliberate exclusion from axiological prevalue of a profession [7, p. 20].

Problems also occur on a stage of professional training at an HEI. Thus, the analysis of curricular, programmes and study books indicated that engineering training does not have succession between study courses. They barely navigate future specialists to conduct creative search, to foster reflection, readiness for innovations and changes in professional activity, etc.

The mandatory cultural components lack not only the ability to forecast and design, but also the ability to understand, interpret and integrate theoretical and practical activities, as well as to organize professional activity.

The Standard does not have any disciplines that focus on professional self-development and career planning and development.

Detachment and isolation of the knowledge acquired is particularly eminent in the process of interdisciplinary project development.

Having analyzed the activities of graduates, authors can draw a conclusion that a future engineer, who has a high grade, for instance, on "Economics" is not able

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to apply this knowledge in his/her professional activity. Besides, more than 70% of final-year students regularly note that professional training does not correspond to the real professional activity.

The authors attempted to find a solution of this problem by investigating expertize of foreign and domestic training of engineering workforce [8]. Thus, the theory and practice of engineering pedagogy at foreign HEIs actively relies on problem-oriented and project-based learning (C. Benjamin, E. de Graaff and others).

At the same time, problem-oriented method allows students to focus on solving a clearly defined problem situation, which motivates them to acquire knowledge needed for problem's solution and stipulates their independent "search" for knowledge from various areas with an aim of further application of it in the process of solving a particular production task.

Project-based learning, including teamwork, is a "prototype" of future engineering activity. Students get experience of comprehensive work of engineering design that intends not only allocation of work functions, but also sharing of responsibility between team members. The key part of project-based learning is the development of abilities on student's cooperation within a group.

These methods are widely introduced as innovations in the majority of foreign HEIs.

Thus, Faculty of Engineering of Leuven Catholic University (KU Leuven, Belgium) provides bachelor students with a course "Problem Solving and Engineering Design". While studying the course students get involved in real engineering practice, team work (6 to 8 students) on interdisciplinary projects, learn to solve engineering problems that require integration of knowledge on a number of disciplines. The main aim of the course is to foster technical and social competences.

In the first semester a website is created to illustrate the problems chosen by students. Within the first week students can try on different roles starting from project manager and ending with a role of a secretary or a treasurer. Teams demonstrate their work through portfolios.

During the second semester students conduct an engineering project, prepare a presentation and a report.

In the third semester students are suggested to participate in "open" projects, i.e. projects that do not have an unambiguous solution. Students propose an engineering solution, create and demonstrate a working model.

Students learn to solve typical engineering problems within this course and then they turn to the development of "open" projects.

This technology fosters the formation of professional (use of not only the fundamental knowledge, but also skills of engineering design and research) and universal competences required for project management. The emphasis is on the development of social competences rather than only technical ones.

Curtin University of Technology (Australia) executes an innovative course "Engineering Foundations: Principles and Communication" that assures fostering of students' communication competences while developing technical projects.

Project design requires students to have communication skills, because being in a role of a client intends that they propose different alternative solutions to each other. Students foster the following abilities: to analyze situations, to write a report, to prepare a project, to formulate conclusions on work results.

Grenoble Institute of Technology (Grenoble INP, France) conducts training of graduates, who are ready to do project work based on consideration and comprehensive assessment of the influence of engineering solutions on society and environment. During a semester master students participate in a project focused on responsibility in engineering decision making. Sponsor industrial companies evaluate students' work. In the framework of the project students foster competences needed for professional engineering activity with emphasis on ethics, social and environmental responsibility, as well as sustainable development.

Aalborg University (Copenhagen, Denmark) has developed an educational model that is based on solving practice-oriented tasks. Students solve proposed tasks in project groups under the supervision of a teacher – a facilitator. University has a unique environment for the development of both professional and universal competences of future engineers.

Йcole Centrale Paris (ECP, France) works on the implementation of teaching and learning methods aimed at the development of key competences that are typical for European engineers, such as leadership, efficient communication, readiness and ability to work in teams, creativity in designing modern industrial production, and social responsibility.

Students get involved in the development of a project "Leadership and Engineering", master a course "Challenges of the XXI Century" aimed at understanding the role of an engineer in solving problems of the XXI century, foster abilities to solve production tasks in the context of uncertainty, work on a group project that is focused on solving a particular topical engineering problem in modern spheres: energy, environment protection, modernized biotechnologies, public healthcare, information, regional development and mobility, and economics and management.

Course work starts with a three-day workshop that concerns topical problems of the XXI century. Students prepare individual reports and then participate in conducting a group project aimed at finding a solution for the identified problem. Each of the tasks is evaluated.

In cooperation with Heriot-Watt University (Great Britain), Tomsk Polytechnic University (TPU, Russia) created a Center for Training and Retraining of the Oil and Gas Specialists.

During the first year of Master programmes students study courses of the 7th (Fall) and 8th (Spring) semesters. Courses are in Russian, but an intensive course on professionally-oriented English language is executed at the same time.

Study classes are conducted in natural conditions (field practices, work at paleontological and geological museums, internships at industrial petro-physical laboratories of JSC "TomskNIPIneft"). The first year ends with a 7-week industrial internship in departments of oil and gas producing partner companies.

The second year (training is mainly in English) includes mostly theoretical courses (lectures, practices, tests, exams) and work (during spring semester) on personal projects.

An important role in training specialists is devoted to their involvement in scientific and research work. Master students get included into group projects on requests from oil and gas companies. In interdisciplinary teams students try on different functions (project developers, geologists, geophysics, extraction engineers, and, of course, practical specialists on drilling, etc.). Thus, they widen and deepen their competency. When presenting their group projects each student defends the results of his/her own part.

Students, who successfully graduate from a Master programme by defending both group and individual projects, receive degrees from two universities: TPU and Harriot-Watt University.

Introducing students to practical problem-oriented activity, as well as to individual work on solving real problems (including "open" engineering problems), facilitates acquiring the experience of fundamental knowledge practical application: conducting joint workshops together with industry representatives, developing and designing projects proposed by companies, including projects executed on premises of enterprises, inviting experts for project mentorship and assessment, allocating students' internships at industrial companies to get to know their corporate culture.

Training system developed in Tomsk Polytechnic University covers education from high school to higher education and professional development and ensures continuous training of elite specialists.

For more than 20 years the university runs a Polytechnic Lyceum (for students of 10th and 11th grades). Training process on a number of courses in the lyceum is supported by the leading professors of TPU.

Together with mass training of students starting from 2004 TPU has been executing a system of Elite Technical Education that covers 4 stages: 1) 1st and 2nd years of bachelor programmes – stage of fundamental education; 2) 3rd and 4th years – professional training, where students learn economics and management of innovative projects, disciplines connected with entrepreneurial thinking, conduct problem-oriented projects in groups; 3) 5th and 6th years (specialist and master programmes) – special training.

Students are involved in group practice-oriented projects. Selection process for the Elite Technical Education system (ETE TPU) is based on an additional testing that determines intellectual abilities and creative potential of students.

Competitive advantages of the Elite Technical Education programme reside in the fact that integration between fundamental knowledge and professional focus is achieved within the study process.

Tomsk Polytechnic University among the first universities in Russia (from 1995) together with leading foreign universities conducts training on eight master programmes within 10 centers of excellence. These master students are notable for their innovative thinking, creativity, ability to integrate research, project, and entrepreneurial activities. They have a grip on the methodology for group design of complex systems, they are able to work in interdisciplinary teams, and they are fluent in professional English. Master students have an opportunity to receive two diplomas: a diploma of Tomsk Polytechnic University and a diploma of a partner university.

The university has a person-centered educational environment with emphasis on students' self-learning under the supervision of teachers [9].

Focusing on the principle of continuous education as on a fundamental pillar provides enhancement of the form of education acquisition. Interlinking of human forces and abilities is the topical issue for professional pedagogy. It allows focusing on *social partnership*.

Aligning interests of an HEI, employers, business leaders and science in terms of adjusting curricular, organization and contents of scientific and research training of HEI students is the leading direction for enhancement of social focus of the modern market economy.

According to "Kommersant. Dengi" journal, Bauman Moscow State Technical University (MSTU) is the leading university in the ranking of universities, whose graduates are highly demanded by the labour market.

High competitiveness, as well as high demand for Bauman students is secured by thorough fundamental training and good knowledge of real industry. The quality of education is achieved by means of integrating science, education and innovative activities, which is supported by traditions of the university, systematic joint high-end research together with enterprises, and indispensable attraction of leading specialists of industry and science for teaching.

Starting from 3rd and 4th years students take part in scientific research of Bauman MSTU. Expectedly, MSTU participates in a state project – "Skolkovo Valley", similar to the American Silicon Valley. Skolkovo is to become the biggest "shooting ground" for new economic policy in Russia. Specific conditions for research and development, including the development of energy and energy-efficient technologies, nuclear, cosmic, biomedical and computer technologies, are introduced on a specially allotted territory.

The idea of Skolkovo creation served as a basis for the development of Futurussia community – an international community of talented scientists, engineers, innovators, who are interested in the process of economic and cultural development in Russia.

Membership in the Community gives "an opportunity to communicate with like-minded people - with those, who have already become professionals in their field. And this is important for personal development" (N. Denisov-Vinskiy – PhD student of Power Engineering Faculty, employee of the Center for Innovation Infrastructure and Youth Entrepreneurship of Bauman MSTU), "a wide ground for self-realization, for acquiring new knowledge" (Yu. Chekhov), "an opportunity to create a "City of the Future", that is firstly built for those, who are involved in innovative activities" (N. Denisov-Vinskiy).

The key idea that Futurussia members face today is to simulate a building Skolkovo city and to live in it. There are several areas of work here. Each member chooses an areas that is close to him, for instance, business, education, e-administration and information environment, programmes for marketing and sociologic research and Skolkovo products promotion on specific markets, etc.

In order to create modern power machines it is essential to receive a thorough fundamental field-specific training both in the specific field and in the areas of economics, psychology and management. For this very reason, students of the Faculty study management, marketing, consulting, along with learning fundamental disciplines. Students can get diplomas of Bachelor, Specialist and Master levels at the Faculty, as well as continue their education at PhD level. "I like the creative style. Bauman School is not only the knowledge; it is a wonderful and very useful school of life" (Aleksandra Saydikova, graduate of Power Engineering Faculty).

The Faculty of Engineering Business and Management operates successfully at Bauman MSTU. The specific nature of the Faculty resides in the integration of engineering and humanitarian training in the field of economics and management. Trained managers and engineers-managers are able to solve problems of production management and organizational management of companies with different forms of incorporation.

When graduating the university young specialists face a choice: to work as an employee, to engage in creative work, including research activity, or to become an entrepreneur. It is not a mere coincidence that the Faculty has a Department of Entrepreneurship and International Activity. Bauman graduates know that success in the modern society can be assured if engineering skills are supplemented with knowledge on economics and basics of entrepreneurship. Many students acquire second higher education degree at the Department of Entrepreneurship and International Activity in parallel with their first degree.

Objectives related to understanding the need for creation and development of professional mobility of a future engineer can be achieved only by perceiving a student as a subject of educational process.

It is essential to note that education, being a subject's function, is proportioned to his individual life course and experience, to specifics of coping with critical moments of professional development, and is determined by the socio-cultural experience and historical past of the professional community that he belongs to.

Hence, future engineers should be involved in the activities on designing forms, methods and contents of education that correspond not only to the actual culture, but also to the opening horizons for future creativity and professional development.

REFERENCES

1. Ob utverzhdenii Kontseptsii dolgosrochnogo sotsialno-economicheskogo razvitiya Rossiyskoy Federatsii na period do 2020 goda (On Approval of the Concept for Long-Term Socio-Economic Development of the Russian Federation until 2020) [Electronic resource]: Russian Federation Government Decree of 17 November 2008 No. 1662-p. – URL: http://www.ifap.ru/ofdocs/rus/rus006.pdf, free. – Tit. from the screen (usage date: 04.09.2016).
2. Naumkin N.I. Metodicheskaya sistema formirovaniya u studentov tekhnicheskikh vuzov sposobnostey k innovatsionnoy inzhenernoy deyatelnosti (Methodological System for Preparation of the Students of Technical Universities for the Innovative Engineering Activities) / N.I. Naumkin. – Saransk: Mordovian State University, 2008. – 172 p.
3. Varnavskikh E.A. Tvorcheskaya inzhenernaya aktivnost spetsialista i realizatsiya metodik ee formirovaniya u studenta v tekhnicheskom vuze (Creative Engineering Activity of a Specialist and Realization of the Methods for Its Formation for Students of Technical HEIs) [Electronic resource] // Pedagog. – 1999. Iss. 7. – URL: http://www.altspu.ru/Journal/pedagog/pedagog_7/a07.html, free. – Tit. from the screen (usage date: 15.09.2016).
4. Lozovskiy V.N. Fundamentalizatsiya vysshego tekhnicheskogo obrazovaniya: tseli, idei, praktika (Fundamentalization of Higher Technical Education. Goals. Ideas. Practice) / V.N. Lozovskiy, S.V. Lozovskiy, V.E. Shukshunov. – SPb: Lan, 2006. – 128 p.
5. Naumkin N.I. Osobennosti podgotovki studentov natsionalnykh issledovatelskikh universitetov k innovatsionnoy inzhenernoy deyatelnosti (Special Aspects of Training the Students of National Research Universities for Innovative Engineering Activities) / N.I. Naumkin [et.al] // Integratsiya obrazovaniya (Integration of Education). – 2013. – Iss. 4. – pp. 4-13.
6. Krylova N.B. Kulturologiya obrazovaniya (Culturology of Education) / N.B. Krylova. – Moscow: Vysshaya Shkola, 2000. – 184 p.
7. Karmin A.S. Kulturologiya (Culturology) / A.S. Karmin. – SPb: Lan, 2003. – 928 p.
8. Chuchalin A.I. Kachestvo ingenernogo obrazovaniya (Quality of Engineering Education) / A.I. Chuchalin. – Tomsk: Tomsk Polytechnic University Publishing House, 2011. – 124 p.
9. National Research Tomsk Polytechnic University [Electronic resource] : [official website]. – Tomsk, 2002-2017. – URL: https://tpu.ru, free. – Tit. from the screen (usage date: 10.10.2013).
10. Moscow State Technical University [Electronic resource]: [official website]. – Moscow, 1997-2016. – URL: http://www.bmstu.ru, free. – Tit. from the screen (usage date: 12.12.2016).

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Generation of Macroregional Network Innovation- and Educational Cluster in the North Caucasian Federal District

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This article validates the generation practicality of the network innovation- and educational cluster, which would combine leading universities of the macroregion, research- and infrastructure entities and the business community. The main difference between the proposed model of the cluster generation and the existing ones is that originally the initiative of cluster establishment comes from entrepreneurs, who are interested in investments in the development of innovation- and educational activity of the macro-region, and the North Caucasian Federal District (NCD) in particular. This article also proposes patterns of networking cooperation of the cluster participants, in order to optimize expenses in the course of cluster creation and operation.

Key words: innovation- and educational cluster, synergy effect, network cluster, cluster policy, networking cooperation, infrastructure of innovation activity.

Currently, the creation of integrated interactive network educational space is one of the major tasks of education system modernization. This can be implemented if comprehensive information- and communication system with broad and in some degree unique functional capabilities is in place. New technologies create the potential for sustainable development of cluster formations in the research- and educational system of higher education. This process generates missing links of the market infrastructure, including distributed virtual research- and educational structures.

At present, numerous policy papers indicate the importance of development of territorial clusters in various forms.

Catering to the needs of the post-industrial paradigm of global development, economic systems change. The cluster policy of leading economically developed countries also changes. It is reflected in the transformation of approaches to the cluster concept. Interactive cooperation forms of innovation parties, network cooperation forms of cluster participants begin to play a more significant role. This helps to overcome territorial and country restraints, and achieve a higher synergy effect in cluster cooperation.

Approaches to the definition of clusters have significantly altered. While in the XX-th century territorial vicinity of its participants, which defined the essence of the cluster, played an important role, in the present interpretation common ideas, goals and their joint achievement with the application of resource-, informational- and financial potential of cluster participants is the key element of the cluster cooperation. In this regard, the authors define the network cluster as a group of independent commercial and (or) non-commercial entities, which are united at the resource level in the technological network to implement a common idea. This technological network provides for the achievement of synergy effect sufficient to produce competitive products or services in the course of innovation-oriented activity as part of the integrated space [1].

From this definition one can see that cluster participants preserve their independence and combine resources as part of the specific technological network to achieve a common goal. A special focus is made on the availability of synergy effect. Moreover, it is stated that this effect would be sufficient to produce competitive products or services. Significantly, the authors do not consider geographic proximity as one of the major motivating factors of cluster generation, although the scientific literature has made a primary focus on this. It is considered, that currently it is not a major factor, but more importantly, cluster participants perform their activities as part of common information- and communication space, which ensures networking cooperation at the cutting-edge level. The factor of innovation orientation is also an important distinguishing feature of the cluster, because clusters are generated where breakthrough advancement in science, technology with further entry into new market niches is expected or performed.

The distinctive feature of the innovation networking cluster is that all participants, that are located in different regions or countries, and united via telecommunication systems, are engaged in the implementation of the common innovation project at various stages of its life cycle. It means that within one cluster, all participants of the innovation process unite and cooperate with each other from the birth of an innovative idea to its commercialization and market entry. At that, territorial concentration does not play a key role.

The majority of existing innovation clusters in Russia are primarily generated on the geographic principle. In order to convene all participants in the same area within one region, the Federal government spends enormous financial resources on the cluster infrastructure. At the same time, advanced economies depart from the above principle and focus all their efforts on the ultimate goal, optimizing costs on the development of innovative projects through the use of innovative organizations resources from various regions and even countries. This significantly increases the competitiveness of innovation projects, reduces transaction costs and makes it possible to involve best specialists from different countries in this project.

To create and develop the innovation- and educational cluster (IEC), one needs economic strenth, high level of human capital, and also a certain degree of infrastructure development of innovation activity. Infrastructure development of innovative activity is declared as one of the main priorities of Russia's innovation system. [2]. Since the beginning of the 1990-ies, the Russian Federation has created more than 1,000 infrastructure objects of innovation activity, including 5 special economic zones of technical innovation, 10 nanocentres, 13 prototyping centers, 16 certification centers and testing laboratories, 29 centers of information- and consulting infrastructure, more than 50 engineering centers, which combine 28 regional engineering centers, 20 engineering centers as part of leading technical universities, 9 engineering centers of pilot innovative regional clusters, etc and others, 114 technology transfer centers, 160 industrial parks, 200 business incubators, 300 centers for collective use. Russia established infrastructure objects of innovation to ensure the development of science. It includes the Advanced Research Foundation, the Federal Agency for Scientific Organizations, the Russian Found for Research, 2 national research centers and 14 science cities. The system of development institutions is in place, and covers Rosnano Corporation, Skolkovo Innovation Centre, the Russian Venture Company (RVC), the "Web-innovations" Foundation and others. The organization of more than 200 regional clusters has been initiated, including 26 pilot innovative regional clusters, supported by the Federal budget and 35 technology platforms, which also belong to the innovation infrastructure [3].

As indicated in the Strategy of Innovative Development of the Russian Federation until the year 2020, achieving self-sufficiency has been a fundamental challenges of infrastructure development of recent innovation efforts, and this issue still remains unsolved. From 2007 to 2014, the Federal and regional budgets allocated 684.4 billion roubles on infrastructure innovation. It included 92.1 billion rubles to support small- and medium business programmes, 281.1 billion rubles for the capitalization of development institutions, 67.7 billion rubles for the generation of innivation infrastructure in the Russia, 243.5billion roubles for state guarantees and guarantee funds [4].

In the course of these efforts, a "chronic disease" of public-private projects has been revealed, when significant government spending was not supported by planned extrabudgetary funding, and the increase in costs was not accompanied by proper increase in revenues from innovative infrastructure projects and their contribution increase in Russia's economy. One might as well say that the issue of reaching the innovation infrastructure self-sufficiency has not been resolved.

In our opinion, the issue is not only that Russian clusters are created by the front-office decision, but also in the development priorities of clusters. Oftentimes, clusters align themselves with prestigious industries and interests of major companies, that is why it limits development prospects of these clusters and impairs their efficiency. Not in every instance are the interests of small and medium-sized businesses taken into account. It is clear from the structure of cluster governing bodies, which are often managed by either State government agencies or State-owned companies. Thus, it does not create a sustainable platform for internal cooperation and development.

It is very important to establish the efficient management system within clusters focused on the interests of cross-sectional participants, on harmonization of programmes and development strategies of cluster participants.

The authors propose to establish the networking innovation- and educational cluster, which would unite leading universities of the macroregion, research-, infrastructure organizations and innovative entrepreneurship.

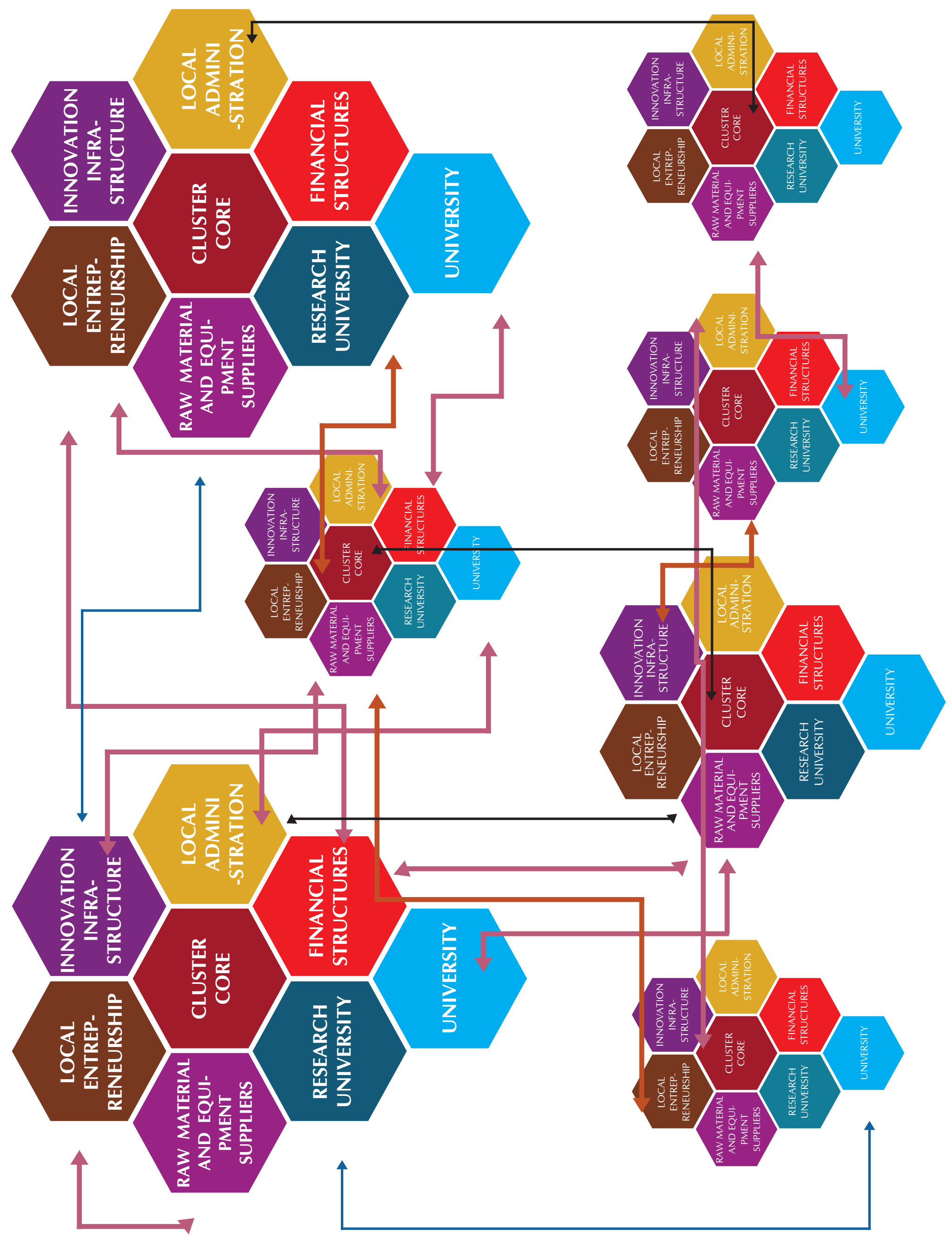
Advanced counries achieve their high level of innovation namely through the active integration of higher education- and research organizations in business processes of regions. The direct dialogue between regional authorities, research- and business community is required. Cluster development with network technologies has been recognized as the most efficient form of this cooperation throughout the world. In this regard, the establishment of the networking inter-regional North Caucasian Federal District innovation- and educational cluster seems pertinent.

In the proposed model of the multi-core networking innovation- and educational cluster (fig. 1), each "bunch" symbolizes the innovation system of the region, which includes leading universities, companies and organizations, regional governments, financial institutions, development institutions, venture capital funds and elements of innovation infrastructure. The above entities, implementing online cooperation within its regional segments, have an additional opportunity to establish efficient networking cooperation at the interregional level. This allows to accumulate resources in most important areas of regional econony and to involve most competitive professionals and experts to perform innovation projects, and significantly reduce all transaction costs of cluster participants.

This model of macro-regional networking innovation- and educational cluster proposes to generate a unified information- and communication environment for all macro-regional innovation participants. In fig. 2, this environment is arbitrarily highlighter in blue. It means that each macro-regional innovation cluster is included in the proposed system, and its members have an opportunity to cooperate both regionally and interregionally. This would give the impetus to previously generated projects and expedite the creation of new ones.

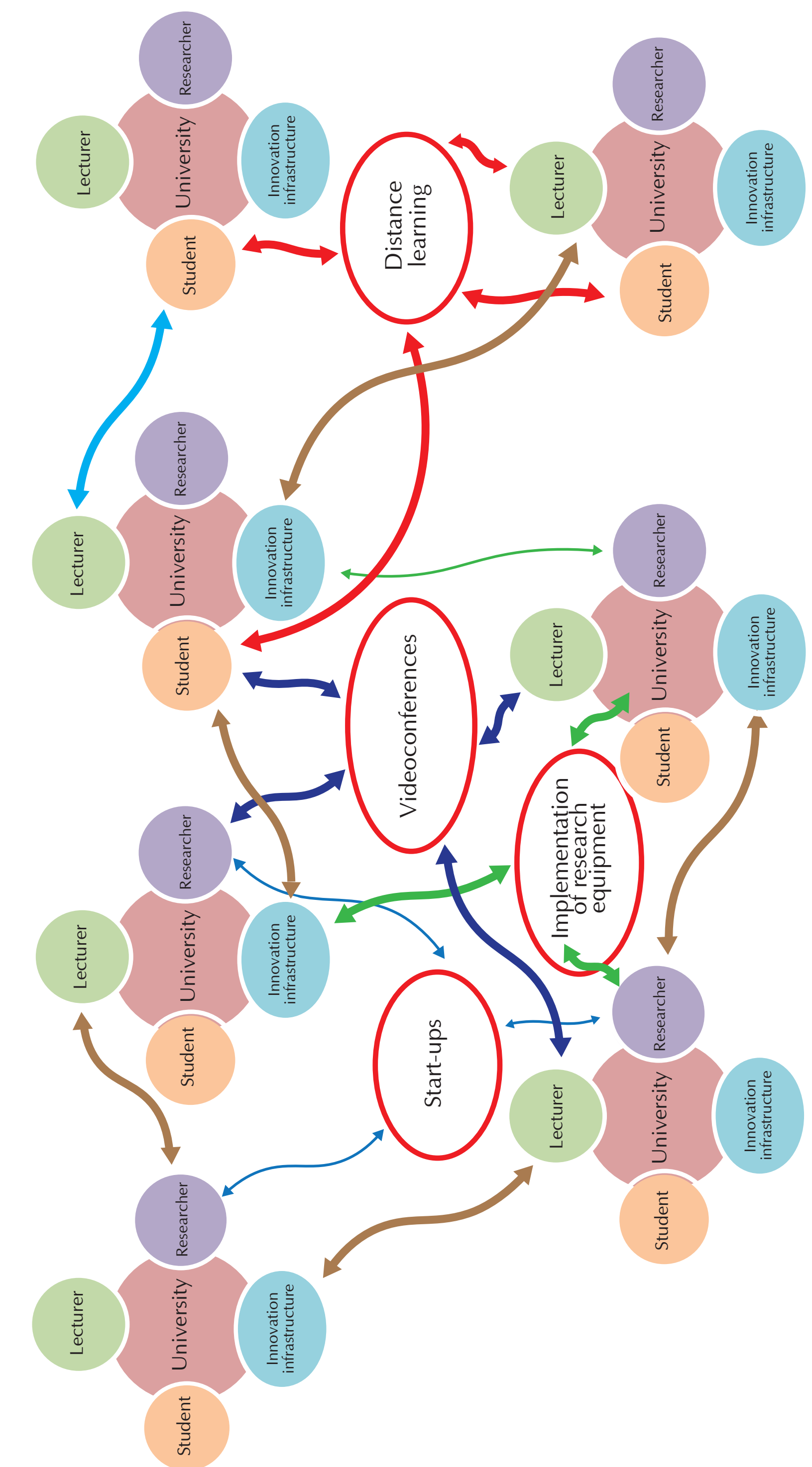
The information- and communication system of macro-regional networking Innovation- and Education Cluster creates integrated information- and communication

Fig. 1. Model of regional networking multi-core innovation- and educational cluster of the North Caucasian Federal District



space of the networking cooperation of the entire operation of this cluster. To intensify their efforts under the information- and education cluster, both management and staff of these organizations must be involved in the network environment of the cluster. To achieve this, participants must have a corporate network environment

Fig. 2. Cooperaton diagram of macro-regional universities in education and research under networking innovation- and educational cluster of the North Caucasian Federal District



for all employees to be able to work on the networking basis. Most importantly, this internal network environment must be adapted to the cluster network environment.

The application of the proposed pattern of networking cooperation of micro-regional universities is also possible under previously generated educational clusters. In particular, "North Caucasus" Scientific and Educational Medical Cluster of the North Caucasian Federal District, which was created pursuant to the order of the Russian Federation Ministry of Health № 844 as of 26.11.2015 "On arrangement of work on generation of scientific and educational medical cluster" [5], would operate more efficiently if its members used networking information system of the innovation- and educational cluster. Networking cooperation can provide the following advantages for the cluster:

- shared library of information resources;
- distance learning of students;
- organization of online lectures of professors at several universities simultaneously;
- implementation of modules, which could help students choose professors in particular courses of study in one of the universities of educational cluster;
- possible involvement of therapeutic- and clinical centers in the educational process (e.g., live video feed of complex operations);
- possible selection of clinical sites for medical resident's practice.

This is an incomplete list of benefits that the scientific- and educational medical cluster of the North Caucasian Federal District would gain, if it were involved in the proposed model of networking innovation- and educational cluster. All the above- mentioned competitive advantages of networking cooperation of regional universities within the cluster are applicable not only to health cluster, but also to all universities of the North Caucasian Federal District.

Networking innovation- and educational cluster of the North Caucasian Federal District creates favorable conditions for education modernization of the macro-region based on implementation of networking educational programmes, e-learning, distance learning technologies and remote operation.

The network approach to the development of the North Caucasian Federal District universities is currently a topical issue and it requires careful consideration. Participants of the interregional innovation- and educational cluster of the North Caucasian Federal District cooperate by the distributed virtual networking organization, which combines traditional and electronic forms.

The competitive development of universities of the North Caucasian Federal District is possible if the system of open education is in place. It is namely open educational technologies, networking cooperation between universities, academic mobility and introduction of distance learning in education that represent major tendencies of universities development.

The infrastructure of information- and communication system within the information- and educational cluster will also make it possible to reform university management system and to ensure transparency of management activities. Networking cooperation will promote more speedily interaction of the Board of Rectors of universities of the North Caucasus Federal District and could assist in holding conferences and meetings in the remote- and protected format.

Thus, the inter-regional innovation- and educational cluster acts as an institutional resource, which helps to upgrade organizational and economic system of the North Caucian Federal District universities and to enhance efficiency of the innovation system of the regional economy.

The results of this study facilitate the realization of the project of generation of the distributed innovation- and educational cluster of the North Caucasian Federal District. The cluster in question provides for a distributed fourth generation-technopark and a virtual business incubator. In total, the project is 90% complete. Under the project, professional social network has been created and is in operation. It provides a unique identification of the network participants. The project also involves a global innovation- and educational portal, an all-Russian online community of college graduates and a system identification- and support of individuals with outstanding abilities.

REFERENCES

1. Savzihanova, S.Je. Rol' klastera v razvitii jekonomiki regiona i povyshenii ego konkurentosposobnosti // Rossijskoe predprinimatel'stvo. – 2014. – № 15. – pp. 95–102.
2. Nauchno-metodicheskoe obespechenie innovacionnogo razvitija obrazovatel'nogo klastera v uslovijah integracii nauki, obrazovanija i proizvodstva (dlja rukovoditelej, prepodavatelej i masterov proizvodstvennogo obuchenija uchrezhdenij sistemy professional'nogo obrazovanija, nauchnyh rabotnikov i aspirantov): nauch.-metod. posobie / R.S. Safin, A.R. Masalimova, R.G. Zjaljaeva, E.L. Matuhin; pod nauch. red. G.I. Ibragimova. – Kazan': Danis, 2014. – 109 p.
3. Sistema menedzhmenta dlja upravljajushhih kompanij innovacionnyh territorial'nyh klasterov Rossijskoj Federacii [Jelektronnyj resurs]: otchet / OAO RVK, NIU Vyssh. shk. jekonomiki, CSR "Severo-Zapad". – [M.: b. i.], 2014. – 250 p. – URL: http://www.rvc.ru/upload/iblock/946/201403_management_companies_clusters.pdf, svobolnyj. – Zagl. s jekrana (data obrashhenija: 11.11.2015).
4. Povestka razvitija innovacionnoj infrastruktury v RF [Jelektronnyj resurs]: rezjume dokl. Min-va jekon. razvitija i OAO RVK / A.E. Shadrin, E.B. Kuznecov, V.N. Knjaginin i dr. – [B. m.: b. i., b. g.]. – 25 p. – URL: http://www.engineering-info.ru/wp-content/uploads/2015/09/Povestka_razvitia_innovacionnoy_infrastrukturi.pdf, svobodnyj. – Zagl. s jekrana (data obrashhenija: 11.03.2016).
5. Ob organizacii raboty po formirovaniju nauchno-obrazovatel'nyh medicinskih klasterov [Jelektronnyj resurs]: prikaz Min-va zdravoohranenija Ros. Federacii ot 26.11.2015 g. № 844. – URL: http://stgmu.ru/userfiles/depts/cluster/Prikaz_844.pdf, svobodnyj. – Zagl. s jekrana (data obrashhenija: 11.03.2016).

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Engineering Modeling: Educational Practice Analysis

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The paper studies a wide variety of additional education programmes and courses in engineering modeling ranging from radio technical simulation and robotics to mathematical modeling. It provides a detailed analysis of the courses according to some particular criteria. It proves that the programme implementation at different education levels depends on specific features of the institute and target student audience.

Key words: engineering modeling, design, mathematical modeling, 3D-modeling, robotics, additional education.

Introduction

Training highly-qualified staff in the sphere of engineering modeling and design is a complicated and long process. Therefore, it is of great importance to lay down the firm theoretical foundation as soon as possible to improve engineering educational programmes, i.e. to train future professional staff as early as at school. However, based on the school curriculum it is impossible now to implement engineering components without updating the curriculum and introducing additional specific disciplines. As a result, development of engineering design programmes is possible on the basis of additional education. Hence, search for and analysis of most efficient educational techniques and practices of teaching engineering design disciplines is a topical task.

Analysis results and discussion

The performed analysis of existing engineering design curricula and programmes for senior schoolchildren has made possible to distinguish several categories of the given profile programmes implemented at various educational institutions. These are additional courses which are taught at school in the form of elective computer modeling courses as a means to increase efficiency of teaching math, physics, and biology. The courses are provided by the additional education centers and students' universities communities, such as "School of Young Physicist", "School of Young Technician" etc., to promote engineering professions, attract schoolchildren, and improve their awareness in career choice, increase the quality of professional engineering education thanks to earlier professional guidance. There are also courses offered by various commercial educational centers and those provided within the additional general educational development engineering programmes held at Centers of Children's and Youth's creativity.

The analyzed education programmes can be grouped into the following profile categories:

- sports and radio-engineering modeling [1–4];
- computer modeling and robotics [5–11];
- courses on specialized software products [12–15];
- mathematical modeling [16–17].

This classification allows covering all existing engineering design educational programmes on the open access and arranging them by "simple-to-complex" principle. To perform comprehensive analysis of programme and course data, the following criteria were used:

1. Novelty.
2. Distinguishing features of analogues programmes.
3. Time consumption (the number of hours).
4. Programme extension.
5. Conditions.
6. Target audience.
7. Programme content.
8. Forms and methods of programme outcomes.
9. Materials and equipment, technical means.
10. Availability of distance-learming programmes.
11. Expected outcomes of the programme.
12. A criterion defining a choice of this or that course is open access to programme content. It is impossible to estimate its relevance to our research without this factor.

The programmes included in the sports and radio-engineering modeling group are the first stage in learning engineering modeling and are usually implemented at Centers of Children's and Youth's creativity, Yong Technicians' Centers, Centers of Children's and Youth's Engineering and other similar organizations. The target audience of such courses covers a wide age range, from 7 to 18. The programmes of primary engineering modelling intended for young school age children have not been investigated within the given research, but they lay the foundation for further effective acquisition of educational engineering programmes.

In terms of time consumption of the given courses, they are the longest – from 1 year to 4 years, 72–216 hours each.

The analyzed programmes are focused on development of engineering thinking, inventive skills, visual and spatial thinking as well as design competencies. It should be underlined that due to the absence of drawing discipline in the school curriculum, these courses allow acquiring the necessary skills of individual drawing, developing combinatorial thinking and is a source of developing spatial images which is basic for not only future engineers but also specialist of any profile [18-19].

The next complexity level comprises the programmes of "computer modeling and robotics" group. The target audience of these courses includes also a wide age range of both pupils and students. These courses are implemented at the Centers of Children's and Youth's Creativity, open distant education platforms, and at colleges and universities, as they are of a wide range and now are in great demand. The extension of the given education programmes can also be long enough – from 14 days to 4 years.

The considered courses are aimed at pupils' acquiring basic knowledge in fundamental electrical engineering and robotics as well as developing 3D-models and their visualization. Pupils are taught to make radio-controlled and programmed robots independently, plot 3D-models for various fields of science and engineering. The creative skills and design competencies are efficiently developed. Some analyzed courses imply a transition from modeling (copying the suggested model) to design (creation of individual operational contraction using specified parameters). However, this approach requires serious methodical preparation, search for a balance between classes and independent work. One needs to take into account group diversity not to lose pupils' interest in the training outcomes, for example, at multiple playback of simple models or "bogging down" in individual project, for completion where the acquired skills are not enough to complete the task. Different kinds of competitions, which are a logic completion of such courses, are a basis for developing leadership, independent work, and teamwork skills.

The universities implement the given courses as a part of the main curriculum within profile engineering training and allow students to acquire design and research competencies. It should be noted that profile-related subjects are not included in the research scope, but they demonstrate the courses continuity at different education levels. Thus, it is obvious that effective training of qualified engineering staff is a rather long and multi-aspect process.

The category of "courses on specialized software products" is a subsequent stage in engineering training, which presents a higher and more complicated level of knowledge. The target audience of the given courses is diverse, but they are mostly experienced specialists in the sphere of engineering design and modeling who need to learn this or that specific software or sufficiently improve their skills. These programmes are mostly designed for senior schoolchildren [20–21], rarely for other groups. As a rule, the programmes are implemented at commercial educational centers or specialized additional vocational education centers of universities. It is necessary to note that this category includes the most number of engineering modeling programmes with distant learning. In terms of time consumption, these programmes are the shortest, from 1 to 5 days or from 16 to 40 academic hours.

The most complex programmes to learn are referred to the "mathematical modeling" group and implemented, as a rule, at universities only as a part of the main engineering curriculum [22]. In this case, even at the Bachelor level both theory and practical application are delivered as a part of the given disciplines [23–24]. More deep insight into these disciplines is given at Master and highly qualified staff training courses. Within the given group 2 programmes were analyzed. The target audience is Bachelor students. The time consumption is from 144 to 216 hours. This group of programmes is focused on development of students' theoretical fundamental knowledge in the sphere of mathematical and geometrical modeling as well as its application in mathematical model design in different sphere of science and technology [23].

Detailed analysis of engineering design curricula and courses has shown that in most cases the authors neither show application of new methods and techniques nor indicate the distinguishing features of the courses taught, i.e. their specificity in comparison with analogues. Hence, one can conclude that on the whole the course designers do not always possess sufficient competencies of methodical programme description.

As a result of engineering modeling programme popularity, the target audience is of wide age range from junior schoolchildren to university graduates and specialists working in this sphere. Therefore, it is necessary to consider engineering modeling programmes and courses for senior schoolchildren as a constituent of general engineering training system, since an engineer is learning all his/her career long. To present a holistic vision, the analysis additionally includes the programmes intended for different target groups, not only for senior schoolchildren.

One of the key criteria is classroom technical equipment. According to the analysis, the level of technical base in the institutes is very diverse. The content of curricula shows that some institutions use a sufficiently wide range of specialized equipment, materials, and software in specially equipped classrooms to develop engineering competencies. Whereas other institutions train students by means of improvised tools only (scissors, glue). It should be noted that Centers of Children's and Youth's Creativity and other institutions of similar profile with limited resources appear to be at a particular disadvantage. Training of highly qualified engineering staff should be performed from the childhood – a period when substantive knowledge, skills and abilities are formed for the further effective learning. For this purpose, the educational institutions need to be equipped with the most advanced technological and software base as it is senseless to train future specialists using out-of-date technology. It is of particular significance that such training courses would be available for any schoolchild. The skill to find the unconventional problem solutions, visual and spatial thinking, interest in knowledge acquiring in the sphere of natural-mathematic sciences – all these are developed when learning engineering modeling and can be practically used in any sphere and are in demand in any job. The competencies acquired contribute to a conscious choice of future profession [19].

Conclusion

It is shown that engineering design courses are implemented at different level of education taking into account specialization of institution. The practice-oriented approach promotes better understanding of theory; clear illustration of the theory knowledge acquired and is a foundation for developing competencies or further mastering the disciplines within the profile engineering training at universities.

REFERENCES

1. Tatarintsev M.I. Radiotekhnicheskoe konstruirovanie: dopolnitel'naya obshcheobrazovatel'naya obshcherazvivayushchaya programma tekhnicheskoi napravlennosti [Radio-engineering design: additional general educational developmental programme of technological profile]. Tomsk: MAOU DO DTDiM, 2016. – 17 p.
2. Yegorov N.B., Ksenofontov V.A. Aviatsionno-sportivnyi modelizm: dopolnitel'naya obshcheobrazovatel'naya obshcherazvivayushchaya programma tekhnicheskoi napravlennosti [Aviation-sportive modeling; additional general educational developmental programme of technical profile]. Tomsk: MAOU DO DTDiM, 2016. – 25 p.
3. Fomina E.B. Avtomodelirovanie: dopolnitel'naya obshcherazvivayushchaya programma [Aeromodeling: additional general educational developmental programme]. Moscow: GBROU KS № 54 OP-11, 2015. – 36 p.
4. Aslanyan A.M. Aviamodelirovanie: dopolnitel'naya obshcheobrazovatel'naya obshcherazvivayushchaya programme [Aeromodeling: additional general educational developmental programme]. Armavir: CNTT, 2015. – 11 p.
5. Budkov V.I. Robototekhnika: dopolnitel'naya obrazovatel'naya obshcherazvivayushchaya programma [Robotics: additional educational developmental programme]. Armavir: CNTT, 2015. – 23 p.
6. Pyatak I.M. Vvedenie v 3D modelirovanie i proektirovanie: dopolnitel'naya obshcheobrazovatel'naya (obshcherazvivayushchaya) programma [Introduction to 3D modeling and design: additional general educational (developmental) programme]. Saint-Petersburg: GBNOU SPb GDTU, 2015. – 13 p.
7. Kucher S.E. 3D modelirovanie: dopolnitel'naya obshcherazvivayushchaya programma [3D modeling: additional general educational programme]. Gatchina: MBOUDOD GC-DOD, 2015. – 13 p.
8. Ivanov D.Yu. Khudozhestvennoe modelirovanie v 3D Max: dopolnitel'naya obshcheobrazovatel'naya programma [Artistic modeling in 3D Max: additional general educational programme]. Saint-Petersburg: Tsentr tekhnicheskogo tvorchestva i informatsionnykh tekhnologii Pushkinskogo raiona Sankt-Peterburga, 2015. – 5 p.
9. Kozlovsky K.N. Robototekhnika: dopolnitel'naya obshcheobrazovatel'naya programma [Robotics: additional general educational programme]. Saint-Petersburg: Tsentr tekhnicheskogo tvorchestva i informatsionnykh tekhnologii Pushkinskogo raiona Sankt-Peterburga, 2015. – 4 p.
10. Arkhitekturnoe modelirovanie sredy: rabochaya programma distsipliny [Architectural modeling of the environment: curriculum]. Krasnodar: Publ KSAU named after I.T. Trubilin, 2015. – 8 p.

11. 3D modelirovanie: rabochaya programma distsipliny [3D modeling: curriculum]. Kazan: Puble KNRTU named after A.N.Tupolev, 2013. – 32 p.
12. AutoCAD 2015: uroven' I (Essentials) (Bazovyi): programma kursa [AutoCAD 2015: level I (Essentials)]. Moscow: ANO DPO SoftLine Education, 2015.
13. Model'no-orientirovannoe proektirovanie: programma kursa [Model-oriented design: course programme]. Moscow: ANO DPO SoftLine Education, 2015.
14. Rabota v sisteme 3ds Max 2014 (dlya starsheklassnikov): programma kursa [Working in 3ds Max 2014 system (for senior schoolchildren): course programme]. Moscow: Uchebnyi Tsentr «Spetsialist» pri MGTU im. N.E.Baumana, 2014.
15. Autodesk AutoCAD 2017/2016 - Osnovy proektirovaniya: programma kursa [Autodesk AutoCAD 2017/2016 – Bases of design: course programme]. Moscow: Uchebnyi Tsentr «Spetsialist» pri MGTU im. N.E.Baumana, 2016.
16. Matematicheskoe modelirovanie: rabochaya programma distsipliny [Mathematical modeling: curriculum]. Novosibirsk: Publ NNISU, 2014. – 11 p.
17. Nachertatel'naya geometriya, inzhenernaya i komp'yuternaya grafika: unifitsirovannyi uchebno-metodicheskii kompleks [Drawing geometry, engineering and computer graphics: unified teaching complex]. Perm: Publ PNIPU, 2013. – 34 p.
18. Bazderov G.A. Professional'naya orientatsiya shkol'nikov na urokakh chercheniya [Professional guidance of schoolchildren at drawing classes]. Pedagogika i sovremennost' [Pedagogy and Modernity]. 2014. № 5. – pp. 34-36.
19. Shabalina N.K., Zhidkova E.V. Rol' inzhenernoi grafiki v proforientatsii [Elektronnyi resurs] [The role of engineering graphics in professional guidance]. Sovremennye problemy nauki i obrazovaniya [Modern problems of science and education]. 2015. № 6. URL: http://www.science-education.ru/ru/article/view?id=23325
20. Mironova N.G., Gudkova T.A. Metodika prepodavaniya inzhenernoi grafiki s primeneniem 2D modelirovaniya v srede [Elektronnyi resurs] [Methods of teaching engineering graphics using 2D modeling in AutoCAD environment]. Nauka-rastudent.ru. 2014. № 10. URL: http://elibrary.ru/item.asp?id=22411299
21. Feoktistova L.A., Miftakhov R.R. Ispol'zovanie metodov 3D modelirovaniya v uchebnom protsesse po inzhenernoi grafike [Elektronnyi resurs] [Use of 3D modeling methods in learning engineering graphics]. Cotsial'no-ekonomicheskie i tekhnicheskie sistemy: issledovanie, proektirovanie, optimizatsiya [Social-economic and technical systems: research, design, optimization]. 2015. V.1. № 2(65). – pp. 32-40. URL: http://elibrary.ru/item.asp?id=23341614
22. Fedotova N.V. Tekhnologiya trekhmernogo modelirovaniya v prepodavanii graficheskikh distsiplin v tekhnicheskom vuze [Technology of three-dimensional modeling in teaching graphic disciplines in engineering university]. Primo aspectu. 2011. V. 9 № 7(80). – pp.132-134.
23. Feofanova L.N., Yermakova A.A. Perspektivy primeneniya komp'yuternykh inzhenernykh tekhnologii v obuchenii [Perspectives in application of computer engineering technologies in education]. Vestnik Volgogradskoi Akademii MVD Rossii [Vestnik of Volgograd Academy of the Ministry of the Interior of Russia]. 2014. № 2(29). – pp.113-119.
24. Kuznetsov M.F. Rol' komp'yuternogo modelirovaniya v prepodavanii fiziki [The role of computer modeling in teaching physics]. Vestnik Khakasskogo gosudarstvennogo universiteta im. N.F. Katanova [Bulletin of Khakassia State University named after N.F. Katanov]. 2012. № 2. – pp.103-110.

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Integrated Laboratory System

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This paper presents an integrated laboratory system, which enables to conduct laboratory work in "Electrical Engineering with the Basics of Industrial Electronics", "Electronics", "Electrical Work" and others in the course of teaching complex electrical and electronic professions. The design of the system enables to perform physical simulation of laboratory work by intgrated plug-in units and also electronic simulation by a personal computer.

Key words: integrated laboratory system, laboratory work, physical simulation, electronic simulation.

Formulation of the problem

The age of technological advances, the intensive development of science, technology and their integration result in complication of nature and structure of professional work. The emergence of new technologies requires more serious training of engineers from specialists of technical institutions. This also concerns future teachers related to vocational education, who are being prepared at teacher training institutions.

Rapid implementation of scientific achievements in production, especially in electrical- and radioengineering, leads to the expansion of educational material in programmes and, as a consequence, to the increase in the period of study. Due to the rapid development of electronic production, i.e. the application of new materials, the implementation of new technologies, changes in hardware components of electrical and radio equipment, it can be said that the society sees a technological challenge, which affects training in educational institutions [3, p. 228].

Because the volume of knowledge, skills and abilities in these professions is so large and constantly growing, it is required to change the professional training content of engineers. On the one hand, there are inconsistencies between rapid technological progress, constantly changing range of electronic manufacture, and on the other hand, operational difficulties in displaying this amount of information in teaching- and programme documentation, textbooks, teaching aids and textbooks. This impacts the training quality of specialists of higher- and vocational education.

Analysis of current research activities and publications

Due to high rates of science and technology progress, the entire education system and professional education in particular, are faced with the efficiency improvement of learning process. The changes in question must be primarily reflected in the curricula, academic programmes, textbooks, manuals and other literature. This is particularly important for specialists in the sphere of complex electrical and electronic professions. Today, they account for approximately 30% of all professions. Workers and engineers associated with these activities have to perform much practical work on assembly, connection, disassembly and adjustment of various electrical and electronic circuits. Correct execution of these operations is achieved by long training during various practical and laboratory work.

It must be noted that currently there is a large range of equipment to perform laboratory work in electrical- and radio-engineering disciplines. Some authors, such as A.I. Bashmakov, A.P. Balashov, I.T. Bogdanov, A.I. Bugayov, M.I. Zhaldak, B.T. Kaminsky, S.S. Kizim, D.I. Panfilov, D.Ya. Tamarchak propose to use in their studies foreign software of electronic versions of laboratory equipment.

Almost in all the laboratory equipment the principle is the same. To perform the specific group of laboratory work, there exists a physical test bench, on which this activity is executed. For example, one test bench is used for the subject "Electrical Equipment", section "Direct Current", another test bench is used for section "Alternating Current", etc. [1, 2, 7, 8, 9].

Purpose of the article.

Justification of the existing technology state of laboratory equipment for complex electrical- and electronic professions and presentation of the existing integrated laboratory system.

Presentation of basic material.

Thus, the relevance and practicability of laboratory- and practical work with unified laboratory equipment are driven by the increased requirements of modern society to the training of qualified engineers-teachers in their current and future activities.

Long-term studies conducted in the Laboratory of Vocational Education and Training (VET) of the International Academy of Human Problems in Aerospace Systems and in the Laboratory of Vocational Education and Training of the Institute of Pedagogy and Psychology of Vocational Education of the Academy of Education of Ukraine have revealed, that to improve the quality of practical training in these professions, fundamentally new laboratory equipment is required. These activities began in 1986 and resulted in manufacturing fundamentally new laboratory equipment [3, p. 371; 8]. Further studies, which continued since 2000, allowed to develop electronic versions of laboratory work.

The unified laboratory system includes unified laboratory equipment [3, p. 371; 8]; teaching materials, which consist of textbooks, manuals and educational software to support training process. This system enables to perform laboratory and practical work, and also to conduct simulated and practical activities, both in small and large classrooms using multimedia equipment. Since it is an integrated system, it can be used to execute work in various disciplines [4, p. 7-18; 5, p. 17-35; 6, p. 5-13]. During production of multimedia versions, copyright software products were developed.

Tablets of laboratory benches, being original development, belong to the basic laboratory equipment [3, p. 189; 8]. A sloping panel, which is a tablet, with the slope angle of 70° to the horizon, is mounted to the top cover on the left-hand side of the bench [3, p. 189].

The colour range of the bench, removable elements, wires and other items are selected according to the requirements of engineering psychology. The tablet for assembly and study of electrical circuits during laboratory work includes five toggle switches (1) to connect and disconnect power supply, ten sockets (2) to connect power source socket (3) and to wire and connect various circuit elements (fig. 1).

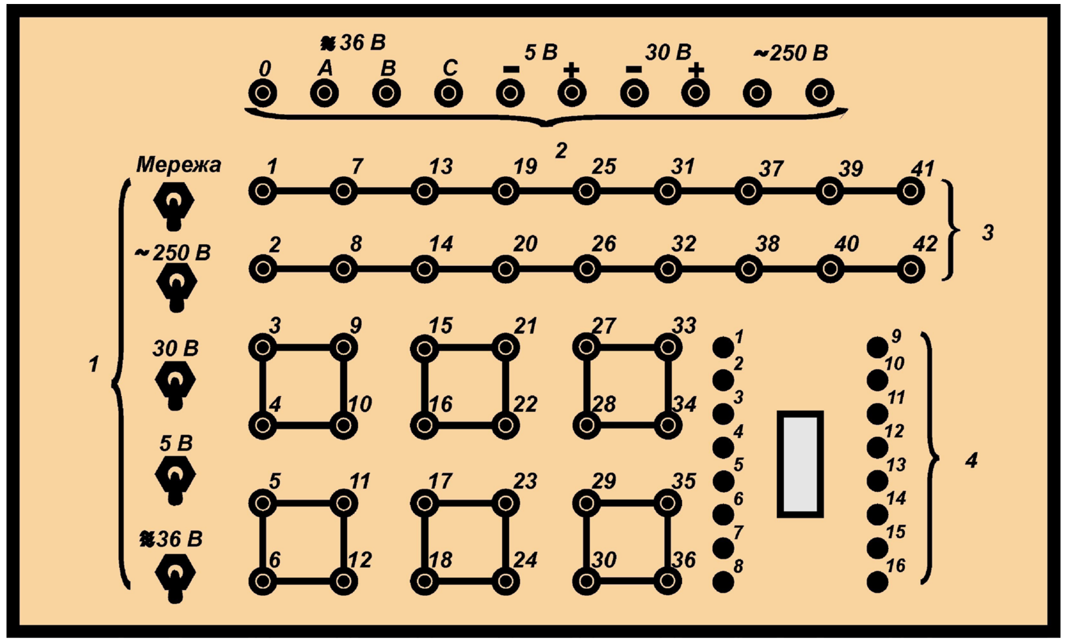
For assembly of electrical circuits using algorithmic instructions, all socket contacts on the perfboard are numbered from 1 to 42.

The socket contacts are interconnected in a certain way from the back side of the panel. These connections are shown on the front side of the panel by the engraving with numbers of socket contacts. The panel for study of integrated circuits (4) is located on the right-hand side of the tablet.

The integrated laboratory equipment uses removable elements (fig. 2), which consist of resistors (fig. 2, a), capacitors (fig. 2, b, c), semiconductor diodes (fig. 2, d) and other elements, which are fastened to dielectric base and soldered to forks in 4 mm diameter [3, p. 191; 4, p. 17].

Since all the elements are integrated, they can be used for assembly of various electrical circuits, i.e. in Laboratory Work No1, which is "Series-, Parallel- and Mixed Connection of Resistors" and other types

Fig. 1. Perfboard with integrated laboratory equipment sockets



of laboratory work. Incandescent lamps of different power are used as the load (resistors) [4, p. 25, 130]. These lamps are screwed in the socket and can be quickly interchanged.

Circuit assembly is performed on the mock-up field of the laboratory bench, and is simultaneously shaped on the PC monitor screen (fig. 1, 3, 4). The installation result of the physical element and its connection

Fig. 2. Removable integrated elements of electrical circuits:
a) resistors; b, c) capacitors; d) semiconductor diodes

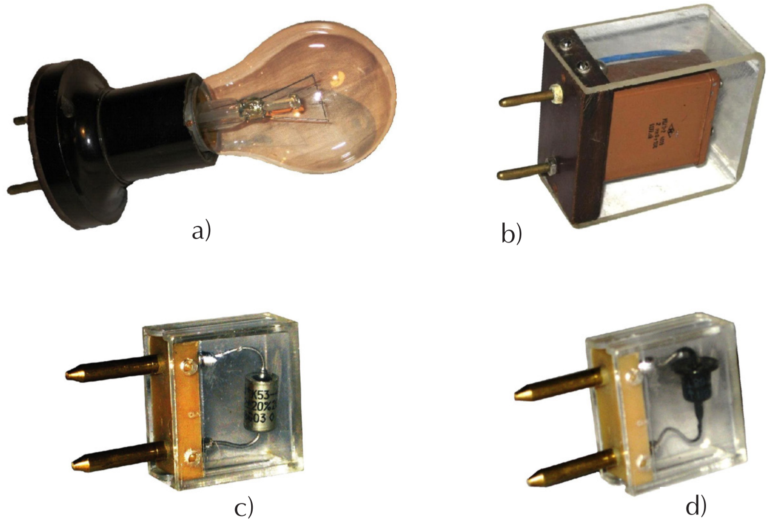
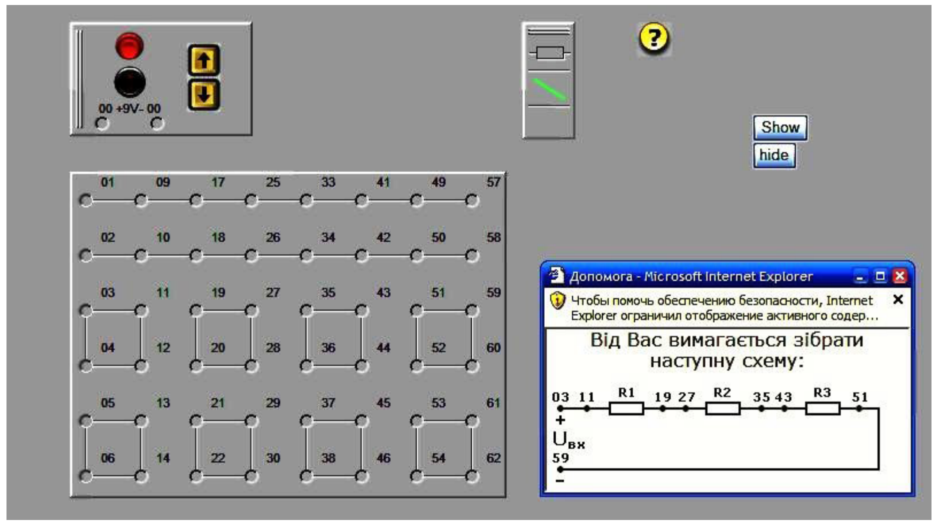


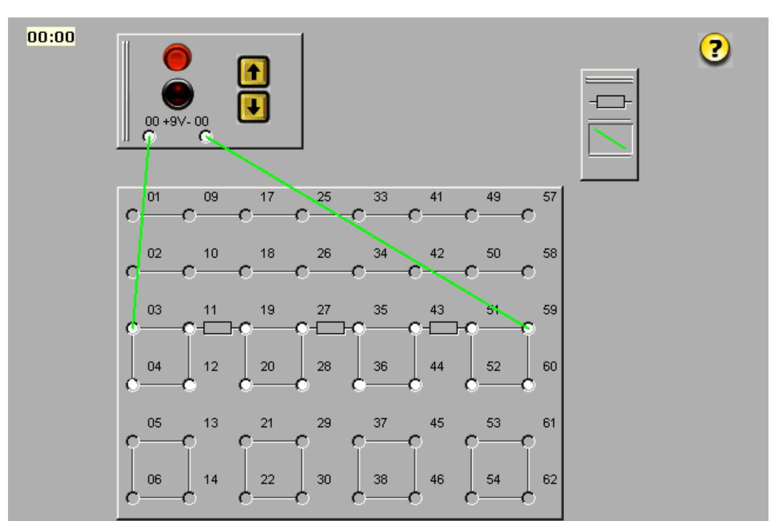
Fig. 3. Mock-up field of laboratory equipment generated by special programme on PC monitor screen



to another one immediately appears on the computer monitor in the form of the electrical circuit, which is the task card analogue (Appendix 1) [4, p. 130]. Therefore, it is possible to visually follow the drawing of the electrical circuit on the screen. It must be noted, that assembly of all electrical circuits is performed as per specially developed algorithms [4, p. 16; 5, p. 29; 7, p. 126].

All the resistors need to be inserted in the sockets, and the wires need to be connected to the power source. If the circuit has been assembled correctly, the socket and the wires actuate. The sockets turn white, and the wires turn green (fig. 4). After power has been supplied to the electrical circuit, the sockets are actuated and turn yellow, and the wires turn red and blue. At that, the resistors are actuated, and electric current b"egins to run through them by way of changing colours: red – white. At the same time, the window with the circuit is displayed (fig. 5).

Fig. 4. Panel of laboratory bench with inserted resistors and actuated sockets



Next step includes results actuation of instrumental gauging and also table actuation with experiment-and calculation results (fig. 6).

During the final step of laboratory work, through the use of formulae students must calculate values of resistors and insert results into the table (fig. 7).

We have adopted a special subprogramme to perform calculations for all types of laboratory work. The arrangement of circuits through the use of range of colours (red, yellow, green) and their application during calculation of relevant programmes made it possible to call these teaching operations "the principle of traffic lights".

Laboratory equipment must comply with several requirements. First of all, it must provide the possibility to perform all types of specified laboratory work, and those which exceed its limits. The second indispensable condition for the system development is the possibility to perform laboratory work in various subjects. And thirdly, which we have been tasked with, is the possibility to use this system as a simulator. This was required because future engineers-teachers had to perform certain techniques of assembly of electrical circuits, until they became automatic. At that, "trial and error method" had to be excluded.

Conclusions

The inspection of the unified system, which has been performed from 2006 to the present time, has revealed its high efficiency revealed its high efficiency. This made it possible:

- to minimize disadvantages of traditional teaching in the course of obtaining knowledge, to acquire certain professional skills and abilities and apply them in practice;
- to reduce preparation time of laboratory equipment prior to performing laboratory work;
- to reduce duration of laboratory work, and thereby increase their amount;

Fig. 5. Elements panel with electrical circuit under study

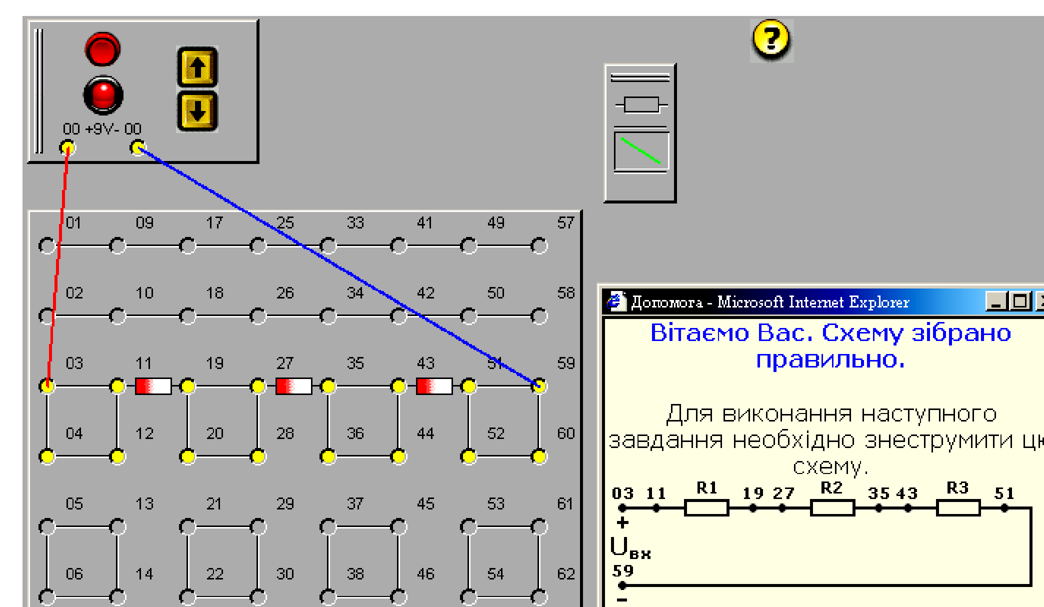


Fig. 6. Actuated panel with measuring instruments and table

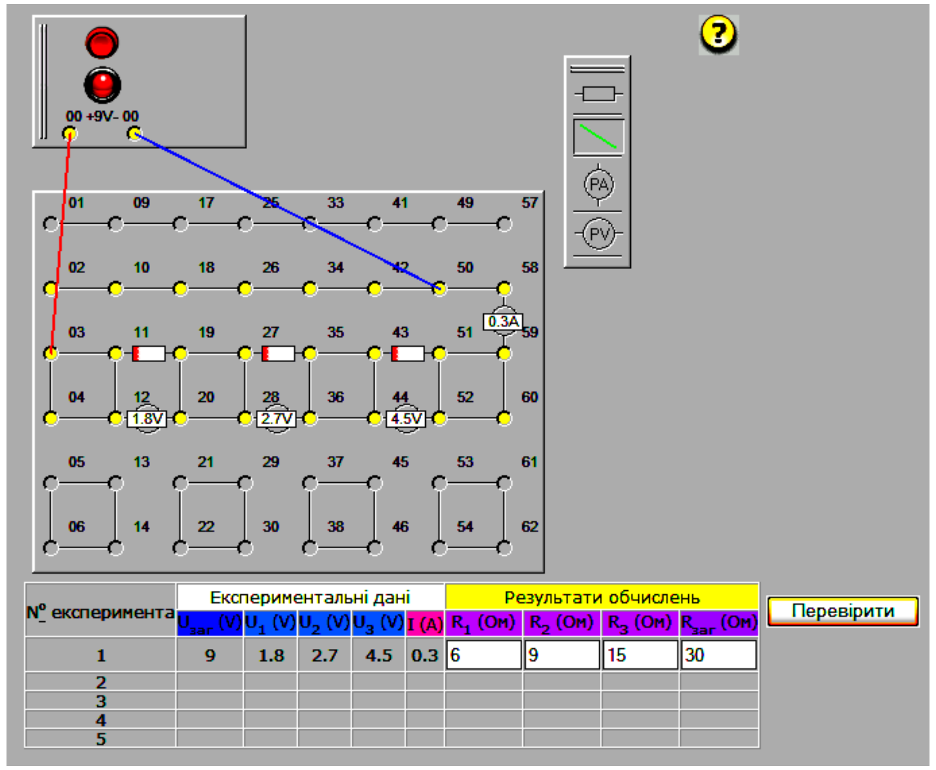
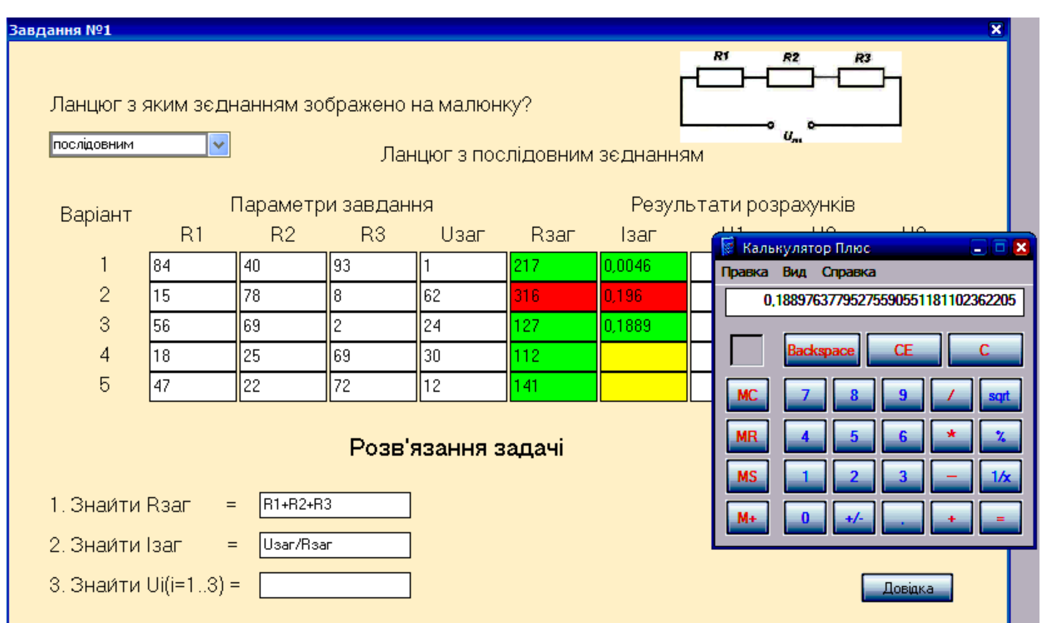


Fig. 7. Reflection of lab work calculation results in boxes and



- to reduce time required for assembly of electrical circuits during laboratory work;
- to exclude "trial and error method" during assembly of electrical circuits in the course of laboratory work;
- to increase the amount of tasks in each subject, in order to test various activities of students;
- to focus training of students on intellectual development by reducing reproductive part and reinforcing creative and search activity.

Further research will be aimed at testing and endorsing practical and laboratory work on the integrated laboratory equipment in the course of other subjects, such as "Electrical Works", "Instrumentation" and also during generation of material content based on these disciplines.

REFERENCES

1. Alehin, V.A. Jelektrotehnika i jelektronika: lab. praktikum s ispol'z. miniatjur. jelektrotehn. lab. MJeL, komp'juter. modelirovanija, Mathcad i LabVIEW / V.A. Alehin, FGBOU VPO Mosk. gos. tehn. un-t radiotehniki, jelektroniki i avtomatiki. – M.: MIRJeA, 2010. – 224 p.
2. Alehin, V.A. Jelektrotehnika i jelektronika. Komp'juternyj laboratornyj praktikum v programmnoj srede TINA-8: ucheb. posobie / V.A. Alehin. – M.: Gorjachaja linija–Telekom, 2014. – 208 p.
3. Anisimov, M.V. Teoretiko-metodologichni osnovi prognozuvannja modelej u profesijno-tehnichnih navchal'nih zakladah: [monogr.] / M.V. Anisimov. – Kiïv; Kirovograd: POLIUM, 2011. – 464 p.
4. Anisimov, M.V. Elektrotehnika z osnovami promislovoï elektroniki: laboratornij praktikum: navch. posib. / M.V. Anisimov. – Kiïv: Vishha shk., 1997. – 160 p.
5. Anisimov, M.V. Radioelektronika: lab. praktikum: navch. posib. / M. V. Anisimov. – Kiïv: Vishha shk., 1995. – 128 p.
6. Anisimov, M.V. Osvitlennja i silove elektroustatkuvannja: lab. praktikum navch. posib. / M.V. Anisimov. – Kiïv: Libid', 1997. – 144 p.
7. Marchenko, A.L. Laboratornyj praktikum po jelektrotehnike i jelektronike v srede Multisim: ucheb. posobie dlja vuzov / A.L. Marchenko, S.V. Osval'd. – M.: DMK Press, 2010. – 447 p.
8. Pat. 2029381 Rossijskaja Federacija, MPK6 C1G09B9/00. Ustrojstvo dlja imitacii jelektricheskih shem / Anisimov N.V.; zajavitel' i patentoobladatel' Anisimov N.V. – № 5004202; zajavl. 8.07.91; opubl. 20.02.95.
9. Rybakov, S.A. Informacionnye tehnologii: lab. praktikum. V 2 ch. Ch. 2. Modelirovanie radiojelektronnyh ustrojstv v programme Electronics Workbench: ucheb.-metod. posobie / S.A. Rybakov, N.I. Shatilo. – Minsk: BGUIR, 2014. – 70 p.

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Summary

HIGHER EDUCATION REFORMS AND ACADEMIC COMMUNITY

A.A. Dulzon
National Research Tomsk Polytechnic University

The paper aims at drawing academic community's and authority's attention to the systemic crisis of Russian higher education and the necessity for country-wide discussion to find rational crisis recovery. It studies the reasons and propagation of the crisis in the higher education and provides some solutions to overcome the problem. It underlines the necessity to involve wider academic community and Russian society in development of technologies to overcome crisis. The relevance of higher education institutions consolidation is put under reasonable doubt. The author highlights the necessity of balanced approach to the competition in the education system, with turning focus on comprehensive cooperation at all levels. The article suggests initial steps to ensure basic conditions for stability and further improvement of the university system efficiency. Therewith, it is crucial to ensure high standards of ethics and integrity of the academic community and management staff of the universities.

ENGINEERING EDUCATION AND TRAINING OF YOUNG ENGINEERS: PRACTICE AND URGENT ISSUES

L.N. Bannikova, L.N. Boronina, Yu.R. Vishnevskiy
Ural Federal University named after the first President of Russia B.N. Yeltsin

The paper studies the role of education system in preparing engineering staff through developing new approaches to designing education programmes and new educational technologies. The conclusions are based on a survey conducted at big Ural industrial enterprises and multi-year engineering student monitoring.

SOCIAL AND PROFESSIONAL ADAPTATION OF UNIVERSITY GRADUATES IN THE LABOUR MARKET

E.V. Politsinskaya, A.V. Sushko
Yurga Institute of Technology (Branch) of the National Research Tomsk Polytechnic University

The article deals with the problem of adaptation of graduates of higher education institutions in the labor market in modern conditions. Based on the results of questionnaires and interviews with young specialists and employers, factors that influence the social and professional adaptation of graduates of higher education institutions are revealed. The viability of interaction of outcome-based, contextual, problem-based and personality-oriented approaches in the educational process to prepare a competitive specialist who is able to successfully adapt in the labor market is explored.

PROFESSIONAL CULTURE AS BASIS FOR ENGINEERING MASTERS' PROFESSIONAL ACTIVITY

Yu.V. Podpovetnaya, A.D. Podpovetny
South Ural State University (National Research University)

Today, the enhancement of engineering master's competitiveness requires a cultural ground. The article justifies that the formation of a cultural ground is achieved through the development of a professional and project-oriented culture, as well as a scientific and methodological culture of master students within the process of engineering education. Both professional and project-oriented, and scientific and tutorial cultures are presented in the article as important qualities of engineering master students; their structural components are identified taking into account future masters' professional activities. The inability of the existing pedagogical models to solve the identified problem sets a task of developing two basic models:

a model providing focused development of a professional and project-oriented culture and a model for the development of a scientific and tutorial culture of engineering master students.

DEVELOPMENT OF INTEGRATED MANAGEMENT SYSTEM IN THE ENGINEERING SCHOOL

I.T. Zaika
Kuban State Technological University
A.P. Kovaleva
Ltd "InzhEkoProekt", Krasnodar

The article relates to integration of quality management systems of the university and the testing laboratory which is a part of the university according to the accreditation requirements to laboratories within the framework of the national accreditation system. It studies alternatives, areas, and degrees of the integration, and suggests a standard approach to IMS (Integrated Management System) based on ISO 9001 and ISO/IEC 17025, that eliminates possible risks in accreditation and allows achieving goals of the integrated management systems.

SOCIALLY ORIENTED APPROACH: PROFESSIONAL AND PERSONAL COMPETENCIES OF ENGINEERING GRADUATES

V.A. Pushnykh
Association for Engineering Education of Russia
I.B. Ardashkin, O.A. Belyankova
National Research Tomsk Polytechnic University

The paper addresses development of engineering graduates' competencies in terms of social position rather than economic, traditional, viewpoint. It emphasizes the importance to develop internal University culture that brings up engineers' responsible attitude to their professional activity. The authors provide some survey data related to TPU students' internal culture research.

PROFESSIONAL-ORIENTED EDUCATIONAL ENVIRONMENT FOR SUPPORTING THE DEVELOPMENT OF CHILDREN'S TECHNICAL CREATIVITY ON THE BASIS OF NETWORK INTEGRATION OF INFRASTRUCTURE RESOURCES OF EDUCATIONAL ORGANIZATIONS

A.V. Isaev, L.A. Isaeva
Volgograd State Technical University

The article presents the concept of network interaction of regional educational organizations within the framework of the programmes supporting children's technical creativity. The urgency of the development of mechanisms for network interaction is considered. An example of realization of network interaction within the framework of the project "Medical measuring systems and robotics" is given. The project is aimed at popularization among schoolchildren and young people of research activities in the field of electronic and technical devices.

MODULAR TRAINING OF SPECIALISTS ON INNOVATIVE DESIGN IN MECHANICAL ENGINEERING

N.K. Krioni, M.B. Guzairov, S.G. Selivanov, S.N. Poezjalova
Ufa State Aviation Technical University

The basic concepts of modular training of specialists on innovative design in mechanical engineering are presented in the article. The concept of continuous innovative training of specialists on the example of the "Innovatics" module is illustrated. The description of educational and methodical teaching materials for "Innovatics" module is provided as an option for realization of electronic and distant teaching and learning methods.

CONCEPT OF SUBJECT AREA "TECHNOLOGY" AS A WAY TO MODERNIZE LEARNING CONTENT AND METHODS AT MODERN SCHOOL

D.A. Makhotin
Moscow City Teacher Training University
A.K. Oreshkina, N.F. Rodichev
Russian Academy of Education
O.N. Logvinova
Academy of Social Management

The paper presents the main idea of "Technology" concept developed by the team in Russian Academy of Education. The concept distinguishes the basis and the main areas of learning content and methodical modernization in technology education at Russian schools.

INNOVATIVE TECHNOLOGY FOR MASS TRAINING: CASE STUDY OF E-COURSE "MECHANICAL ENGINEERING"

S.A. Berestova, N.E. Misyura, E.A. Mityushov
Ural Federal University named after the first President of Russia B.N. Yeltsin

The paper describes a course "Mechanical engineering" set up on the National Open Education platform. The course has a well-balanced system of authors' solutions, special practice-oriented tasks that encourage students to learn and develop engineering thinking. The disguising features of the course are weekly-based structure that allows controlling students' independent work, a practical-cognitive module, and an interactive programming module.

MONITORING MATH COMPETENCY OF IT STUDENTS

S.M. Dudakov, I.V. Zakharova
Tver State University

The paper studies a method to develop testing and assessment materials, which is based on splitting "classical" parts of mathematics into smaller disciplines. It reveals the opportunities of the method in terms of competency-based approach.

CONCURRENT ENGINEERING APPROACH TO TEACHING FUNDAMENTALS OF GEOMETRY AND GRAPHICS IN HIGHER ENGINEERING SCHOOL

E.V. Usanova
Kazan National Research Technical University named after A.N. Tupolev – KAI (KNRTU-KAI)

The paper proves the efficiency of teaching fundamentals of geometry and graphics in the context of concurrent engineering and provides the results of problem- and project based team work performed by students within the scope of blended learning programme. Educational resources of the course comprise materials for declarative learning (educational tools based on GDP – PPT animation, logical schemes with frames, videos) and procedural learning (CAD-systems, graphic tests, different level tasks).

TOWARDS GENERAL DEVELOPMENTAL CURRICULUM "FUNDAMENTALS OF MATHEMATICAL ENGINEERING MODELING"

I.S. Soldatenko, S.V. Sorokin, I.V. Zakharova, O.N. Medvedeva
Tver State University
O.A. Kuzenkov
Lobachevsky State University of Nizhny Novgorod

An innovative general developmental curriculum is suggested for extra school training. It has been developed within the framework of the Russian Education Ministry assignment aimed at establishing nation-wide practice-oriented science and technology clubs for engineering creativity. Distinctive features of the curriculum are project-based learning and an emphasis on mathematical modeling in design and engineering. The purpose of the programme is to promote the engineering profession and education in the country, develop the bases for engineering thinking of a new type in upper form pupils. This type of thinking is required to solve the problems of the new generation associated with intelligent control, artificial intelligence and other issues commonly known as "Future Engineering".

PERSPECTIVES OF SMART SYSTEM MATH-BRIDGE FOR LEARNING ARRAY SORTING METHODS

S.A. Fedosin, A.V. Savkina,
E.A. Nemchinova, N.V. Makarova
Ogarev Mordovia State University

The article proposes the use of Math-Bridge smart system as a tool to train and control knowledge of engineering students in the methods of sorting arrays.

EDUCATIONAL TECHNOLOGIES IN ENGINEERING EDUCATION: MULTIDISCIPLINARY APPROACH

A.A. Shehonin, V.A. Tarlykov,
A.Sh. Bagautdinova, O.V. Kharitonova
Saint Petersburg National Research University of Information Technologies, Mechanics and Optics

The article discusses the issue of implementation of multidisciplinary approach in engineering education through the construction of modular educational programmes, the implementation of network forms of education, as well as the use of interactive learning technologies. It is emphasized that the use of interactive technologies in the learning process is the first step in the implementation of interdisciplinarity on the level of educational programme's content aiming to foster competences of future engineer.

INTERDISCIPLINARY PROJECT – BASIS FOR DESIGNING STUDY PROGRAMMES

A.A. Shehonin, V.A. Tarlykov,
A.Sh. Bagautdinova, O.V. Kharitonova
Saint Petersburg National Research University of Information Technologies, Mechanics and Optics

The specifics of engineering activity lie at the root of projects' implementation. An ability to independently develop and implement projects, as well as to assess their impact and significance is a necessary competence of each graduate. Thus, the core component of training competitive specialists is the introduction of interdisciplinary projects to the learning process. These projects are discussed in the article as a basis for designing of professional study programmes for higher education.

VIRTUAL LABS IN ENGINEERING EDUCATION

S.V. Sorokin, I.V. Sorokina, I.S. Soldatenko
Tver State University

The article deals with the use of virtual labs in engineering education. The programmes which allow simulation of electronic circuits and robotic systems have been considered. The analysis is based on the use of virtual labs in the distant course "Practical engineering education" for pupils. The programme is designed by the authors.

REWARDING LEARNING OF MATHS IN ENGINEERING SCHOOLS: LABORATORY WORKS

V.A. Akimushkin, S.N. Pozdnyakov,
A.S. Chukhnov
Saint Petersburg State Electrotechnical University "LETI"
S.V. Rybin
Saint Petersburg State Electrotechnical University "LETI", Saint Petersburg National Research University Information Technologies, Mechanics and Optics

The approach to development and use of laboratory works in training discrete mathematics and mathematical logic is suggested in the article. It is based on the computer tools to develop and improve productive thinking. The works involved are based on modeling subject field, they include target setting which determines students experimental and constructive activities as well as resources for automatical evaluation of partial solutions submitted by students. Experiment results have shown a significant increase in efficiency as compared to the multiple choice tests.

DESIGNING ICT EDUCATION PROGRAMMES BASED ON PROFESSIONAL STANDARDS

I.V. Zakharova, S.M. Dudakov,
I.S. Soldatenko
Tver State University

The article describes experience of the Russian universities in designing education programmes in the field of information and communication technologies based on professional standards.

TOWARDS THE ISSUE OF QUALITY OF ENGINEERING EDUCATION

S.B. Mogilnitskiy, E.E. Dementeva
National Research Tomsk Polytechnic University

The article considers issues related to the quality assurance of higher engineering education, examines the global experience in this regard and ways to deal with the challenges. It is shown that one of the principal mechanisms to ensure and assess the quality of education is a professional and public accreditation (PPA) of education programmes (EP). The purposes and objectives of the professional and public accreditation, benefits for graduates of accredited programmes in the career development of a professional engineer are described. The practice and outcomes of the activities of the Association for Engineering Education of Russia (AEER) in the accreditation of education programmes in the field of engineering and technology are presented.

ANALYSIS OF EVALUATION CRITERIA FOR THESIS

V.P. Kapustin, D.Yu. Muromtsev,
Yu.V. Rodionov
Tambov State Technical University

The article addresses the problem of raising thesis quality. The authors specify what scientific research is, determine its peculiarities, introduce the evaluation criteria for thesis and provide a list of reviewers.

QUALITY OF FURTHER PROFESSIONAL EDUCATION: NEW TRENDS IN ASSESSMENT AND RECOGNITION

V.G. Ivanov, M.F. Galikhanov
Kazan National Research Technological University
N.N. Aniskina
Pastukhov State Academy of Industrial Management

The article deals with the technology of independent assessment and recognition of quality of further professional education.

VOCATIONAL EDUCATION AND TRAINING SCHOOLS IN TERMS OF STUDENT MIGRATION IN RUSSIA: CHALLENGES AND PROSPECTS

S.V. Dryga
National Research University "Higher School of Economics"
D.V. Poletaev
Regional Public Organization "Migration Research Center"

The paper considers social, economic, and demographic effects of attracting foreign students to vocational education and training schools in Russia. The authors investigate challenges and prospects of increasing national share in the export of educational services in this sector.

CAREER GUIDANCE AND COUNSELLING TO DEVELOP ENGINEERING EDUCATION AT SCHOOL AND UNIVERSITY: TECHNOLOGIES AND MODELS

O.V. Shatunova, T.I. Anisimova
Elabuga Institute, Kazan Federal University

The paper deals with psychological and pedagogical aspects of engineering career guidance provided for pupils. It describes the experience of Elabuga Institute, Kazan Federal University, where they efficiently implement career guidance activities and develop engineering education based on interaction between school and university. One of the priorities is to involve pupils into research and technical activities through participating in innovation projects developed by the university.

PRE-UNIVERSITY ENGINEERING TRAINING FOR CHILDREN

I.V. Vylegzhanina
Vyatka State University

The paper considers engineering training provided for children in terms of its objectives, content, methods, and ways of implementation.

FOREIGN LANGUAGE TRAINING FOR ENGINEERING STUDENTS (AIRCRAFT AND HELICOPTER INDUSTRY): SYSTEMIZING TRAINING CONTENT

S.E. Tsvetkova
Nizhny Novgorod State Technical University named after R.E. Alekseev
I.A. Malinina
National Research University "Higher School of Economics"

This paper deals with particularities of content of foreign language training provided to aircraft and helicopter engineering students. The educational information input is suggested to be systematized with regard to learning stages. The authors consider types of linguistic skills and relevant training methods aimed at effective acquisition of the input information.

QUALITY MANAGEMENT COMPETENCY AS AN ESSENTIAL COMPONENT OF PROFESSIONAL QUALIFICATION OF ENGINEERING GRADUATES

S.B. Venig, S.A. Vinokurova
Saratov State University named after N.G. Chernyshevsky

The authors focus on developing quality management competencies conducting the case study of education programme "Materials Science and Technology of Materials". The authors consider the skills of quality management to be crucial for today's engineering graduates and suggest enhancing Bachelor and Master of Engineering curricula with practice-oriented disciplines, modules, and practices, with relevant examples given.

CLUSTER APPROACH TO ENGINEERING TRAINING FOR MACHINE BUILDING INDUSTRY IN SINGLE-INDUSTRY TOWN

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Zelenodolsk Branch of Kazan Innovative University named after V.G. Timiryasov (IEML)
Kh.R. Kadyrova
Zelenodolsk Institute of Engineering and Information Technologies (Branch) of Kazan National Research Technical University named after A.N. Tupolev - KAI

The article describes a cluster approach to engineering training for enterprises of a single-industry town; the case study is a branch of the oldest Kazan technical university. The cluster strategy is implemented via integration of educational institutions and industrial enterprises.

A PRACTICAL EXAMPLE OF PROFESSIONAL STANDARDS INTEGRATION INTO THE EDUCATIONAL PROCESS OF A NATIONAL RESEARCH UNIVERSITY

E.V. Omelyanchuk, O.P. Simonova, A.Yu. Semenova
National Research University of Electronic Technology "MIET"

The article focuses on the issue of aligning HEI study programmes with the present-day circumstances. A problem of major discrepancy between the higher education standards and the requirements of professional community has been indicated. The article justifies as the problem solution the implementation of additional competences which should guide graduates to carry out work functions introduced by professional standards.

MODERN MODELS OF TRAINING A PROFESSIONALLY-MOBILE SPECIALIST

T.A. Fugelova
Tyumen State University

The main reasons hindering the establishment and development of professional mobility of a future engineer in the socio-cultural educational space of a technical HEI are: the orientation of technical universities to the previously established model of training future engineers and the underdevelopment of the content of future engineers' training. A student has to learn the logic of the development of science, learn how to get knowledge, and get engaged in real professional activities within the learning process of a university.

GENERATION OF MACROREGIONAL NETWORK INNOVATION- AND EDUCATIONAL CLUSTER IN THE NORTH CAUCASIAN FEDERAL DISTRICT

M.Kh. Abidov, S.E. Savzikhanova, L.A. Borisova
Dagestan State University of National Economy

This article validates the generation practicality of the network innovation- and educational cluster, which would combine leading universities of the macroregion, research- and infrastructure entities and the business community. The main difference between the proposed model of the cluster generation and the existing ones is that originally the initiative of cluster establishment comes from entrepreneurs, who are interested in investments in the development of innovation- and educational activity of the macro-region, and the North Caucasian Federal District (NCD) in particular. This article also proposes patterns of networking cooperation of the cluster participants, in order to optimize expenses in the course of cluster creation and operation.

ENGINEERING MODELING: EDUCATIONAL PRACTICE ANALYSIS

O.N. Medvedeva, O.V. Zhdanova, I.S. Soldatenko
Tver State University

The paper studies a wide variety of additional education programmes and courses in engineering modeling ranging from radio technical simulation and robotics to mathematical modeling. It provides a detailed analysis of the courses according to some particular criteria. It proves that the programme implementation at different education levels depends on specific features of the institute and target student audience.

INTEGRATED LABORATORY SYSTEM

N.V. Anisimov
Kirovograd State Pedagogical University named after Vladimir Vinnichenko

This paper presents an integrated laboratory system, which enables to conduct laboratory work in "Electrical Engineering with the Basics of Industrial Electronics", "Electronics", "Electrical Work" and others in the course of teaching complex electrical and electronic professions. The design of the system enables to perform physical simulation of laboratory work by intgrated plug-in units and also electronic simulation by a personal computer.

Professional-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 June 01, 2017, AEER has accredited 478 education programmes (first and second cycles) provided by 71 leading universities of Russia, Kazakhstan, Kirgizstan, Tajikistan, and Uzbekistan. The European certification label EUR-ACE has been awarded to 397 programmes. Also, 5 secondary vocational education programmes provided by Russian vocational training colleges have been accredited. The lists of education 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 education 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 education programmes accredited by AEER.

List of Accredited Programmes, Russian Federation (as of 01.06.2017)

	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 2012-2017
3.	210602	INT	Nanomaterials	AEER EUR-ACE® WA	2012-2017 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 2013-2018
2.	280201	INT	Environmental Protection and Rational Use of National Resources	AEER EUR-ACE® WA	2013-2018 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	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	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
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 2012-2014
2.	210106	INT	Industrial Electronics	AEER EUR-ACE® WA	2009-2014 2012-2014

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	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	Kazan National Research Technical University named after A.N. Tupolev				
1.	150600	FCD	Science and Technology of New Materials	AEER EUR-ACE®	2011-2016
2.	160100	FCD	Aircraft Construction and Rocket Production	AEER EUR-ACE®	2011-2016
3.	230100	FCD	Computer Science	AEER EUR-ACE®	2011-2016
	Kazan National Research Technological University				
1.	240100	FCD	Chemical Technology and Biotechnology	AEER	2004-2009
2.	240100	SCD	Chemical Engineering for Innovative Entrepreneurship	AEER EUR-ACE®	2013-2018
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 2012-2015
	Moscow State Technological University "Stankin"				
1.	120100	INT	Mechanical Engineering Technology	AEER	1993-1998
2.	120200	INT	Metal-cutting Machines and Tools	AEER	1993-1998
3.	120400	INT	Machines and Metal Forming Technology	AEER	1993-1998
4.	210200	INT	Automation of Technological Processes and Manufacturing	AEER	1993-1998
5.	210300	INT	Robots and Robotic Systems	AEER	1993-1998
6.	220300	INT	Automated Production Systems	AEER	1993-1998

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	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 2012-2013
9.	210104	INT	Microelectronics and Solid State Electronics	AEER EUR-ACE® WA	2010-2015 2012-2015
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 2012
4.	140609	INT	Electrical Equipment for Aircraft	AEER EUR-ACE® WA	2007-2012 2012
5.	140611	INT	Insulators, Cables and Capacitors	AEER EUR-ACE® WA	2007-2012 2012
6.	140403	INT	Technical Physics of Thermonuclear Reactors and Plasma Installations	AEER EUR-ACE® WA	2010-2015 2012-2015

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	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 2012
20.	200203	INT	Opto-Electronic Equipment and Systems	AEER EUR-ACE® WA	2007-2012 2012
21.	240304	INT	Chemical Engineering of Refractory Non-Metal and Silicate Materials	AEER EUR-ACE® WA	2007-2012 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 2012-2016
31.	210100	SCD	Physical Electronics	AEER EUR-ACE®	2011-2016
32.	140200	SCD	Mode Control of Electric Power Systems	AEER EUR-ACE®	2011-2016
33.	140400	SCD	Electrical Drives and Electrical Drive Control Systems	AEER EUR-ACE®	2011-2016
34.	200100	SCD	Stabilization and Navigation Systems	AEER EUR-ACE®	2011-2016
35.	130500	FCD	Petroleum Engineering	AEER EUR-ACE®	2011-2016

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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 2012-2017
38.	240501	INT	Chemical Technology of Modern Power Engineering Materials	AEER EUR-ACE® WA	2012-2017 2012-2017
39.	140404	INT	Nuclear Power Plants and Installations	AEER EUR-ACE® WA	2012-2017 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 2014-2019
63.	12.04.02	SCD	Lighting Technology and Light Sources	AEER EUR-ACE®	2014-2019
64.	12.04.02	SCD	Photonic Technologies and Materials	AEER EUR-ACE®	2014-2019
65.	15.04.01	SCD	High-technology Physics in Mechanical Engineering	AEER EUR-ACE®	2014-2019
66.	19.03.01	FCD	Biotechnology	AEER EUR-ACE®	2014-2019
67.	12.04.04	SCD	Medical and Biological Devices, Systems and Complexes	AEER EUR-ACE®	2014-2019

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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 2014-2019
70.	21.05.03	INT	Geophysical Methods of Well Logging	AEER EUR-ACE® WA	2014-2019 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
	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
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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
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 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
	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

	Programme Code	Qualifi-cation	Programme Name	Certificate	Accreditation Period
	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
	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
	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
	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 State Aerospace University (National Research University)				
1.	160301	INT	Aircraft Engines and Power Plants	AEER EUR-ACE® WA	2008-2013 2012-2013
2.	160802	INT	Spasecraft and Rocket Boosters	AEER EUR-ACE® WA	2008-2013 2012-2013
3.	24.05.01	INT	Design, Production and Maintenance of Rockets and Space Complexes	AEER EUR-ACE® WA	2015-2020 2015-2020
4.	24.05.07	INT	Airplane and Helicopter Designing	AEER EUR-ACE® WA	2015-2020 2015-2020

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
5.	12.04.04	SCD	Biotechnical Systems and Technologies	AEER EUR-ACE®	2015-2020
6.	01.04.02	SCD	Supercomputing, Information Technologies and Geoinformatics	AEER EUR-ACE®	2015-2020
	Saint Petersburg Electrotechnical University "LETI"				
1.	220200	FCD	Automation and Control	AEER	2003-2008
2.	210100	FCD	Electronics and Microelectronics	AEER	2003-2008
3.	230100	FCD	Computer Science	AEER	2003-2008
4.	200300	FCD	Biomedical Engineering	AEER	2003-2008
5.	210400	FCD	Radio Electronic Systems	AEER EUR-ACE®	2014-2019
6.	210400	FCD	Radiotechnical Devices for Signal Transmission, Reception and Processing	AEER EUR-ACE®	2014-2019
7.	210400	FCD	Audiovision Equipment	AEER EUR-ACE®	2014-2019
8.	210100	FCD	Electronic Devices	AEER EUR-ACE®	2014-2019
9.	200100	FCD	Information and Measurement Technique and Technology	AEER EUR-ACE®	2014-2019
10.	200100	FCD	Laser Measurement and Navigation Systems	AEER EUR-ACE®	2014-2019
11.	200100	FCD	Devices and Methods of Monitoring of Quality and Diagnostics	AEER EUR-ACE®	2014-2019
12.	231000	SCD	Development of Distributed Software Systems	AEER EUR-ACE®	2014-2019
13.	010400	SCD	Mathematical Provisions and Software of Computers	AEER EUR-ACE®	2014-2019
14.	220451	SCD	Automation and Control of Industrial Complexes and Mobile Objects	AEER EUR-ACE®	2014-2019
15.	220452	SCD	Automated Control Systems for Sea Vehicles	AEER EUR-ACE®	2014-2019
16.	220453	SCD	Shipborne Information and Control Systems	AEER EUR-ACE®	2014-2019
17.	140452	SCD	Automated Electromechanical Complexes and Systems	AEER EUR-ACE®	2014-2019
18.	230161	SCD	Microsystem Computer Technologies: Systems on Chip	AEER EUR-ACE®	2014-2019
19.	230162	SCD	Distributed Intelligent Systems and Technology	AEER EUR-ACE®	2014-2019
20.	230151	SCD	Computer Technologies in Engineering	AEER EUR-ACE®	2014-2019
21.	201051	SCD	Biotechnical Systems and Technologies of Rehabilitation and Prosthetics	AEER EUR-ACE®	2014-2019
22.	201053	SCD	Information Systems and Technologies in Patient Care Institutions	AEER EUR-ACE®	2014-2019
23.	210153	SCD	Electronic Devices and Equipment	AEER EUR-ACE®	2014-2019
24.	210176	SCD	Physical Electronics	AEER EUR-ACE®	2014-2019
25.	210152	SCD	Microwave and Telecommunication Electronics	AEER EUR-ACE®	2014-2019
26.	211006	FCD	Information Technologies for Radio Electronic Engineering	AEER EUR-ACE®	2014-2019
27.	211008	FCD	Information Technologies in Microwave Electronic Engineering	AEER EUR-ACE®	2014-2019
28.	11.04.04	SCD	Nanoelectronics and photonics	AEER EUR-ACE®	2015-2020
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

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
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
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

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
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
3.	11.04.04	SCD	Electronic Devices and Facilities	AEER EUR-ACE®	2015-2020
4.	11.04.02	SCD	Telecommunication Networks and Communication Devices	AEER EUR-ACE®	2015-2020
5.	11.04.02	SCD	Satellite Communication Systems	AEER EUR-ACE®	2015-2020
	Siberian Federal University				
1.	210200	SCD	Microwave Equipment and Antennas	AEER EUR-ACE®	2010-2015
2.	230100	SCD	High-Performance Computing Systems	AEER EUR-ACE®	2010-2015
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

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
5.	210100	FCD	Electronics and Microelectronics	AEER EUR-ACE®	2012-2017
6.	200100	FCD	Equipment Engineering	AEER EUR-ACE®	2012-2017
	Tambov State Technical University				
1.	210201	INT	Design and Technology of Radioelectronic Devices	AEER	2006-2011
2.	140211	INT	Electrical Supply	AEER	2006-2011
	Togliatty State University				
1.	140211	INT	Electrical Supply	AEER EUR-ACE® WA	2009-2014 2012-2014
2.	150202	INT	Industrial Welding Technology and Equipment	AEER EUR-ACE® WA	2009-2014 2012-2014
3.	151002	INT	Mechanical Engineering Technology	AEER EUR-ACE® WA	2009-2014 2012-2014
4.	22.04.01	SCD	Welding and Soldering of Advanced Metal and Non-Metal Inorganic Materials	AEER EUR-ACE®	2012-2014
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 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
	Transbaikal State University				
1.	21.05.04 (130400.65)	INT	Open Mining	AEER EUR-ACE® WA	2015-2020 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 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 2012
5.	190603	INT	Transport and technological machinery and equipment service (oil and gas production)	AEER WA	2007-2012 2012
6.	190701	INT	Transportation organization and transport management (automobile transport)	AEER WA	2007-2012 2012
7.	130602	INT	Oil and Gas Fields Machinery and Equipment	AEER EUR-ACE® WA	2008-2013 2012-2013

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
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 2012-2013
10.	240401	INT	Chemical Technology of Organic Substances	AEER EUR-ACE® WA	2009-2014 2012-2014
11.	240403	INT	Chemical Engineering of Natural Power Supplies and Carbon-base Materials	AEER EUR-ACE® WA	2009-2014 2012-2014
12.	240801	INT	Machines and Apparatus of Chemical Production	AEER EUR-ACE® WA	2009-2014 2012-2014
13.	280201	INT	Environmental Control and Rational Use of Natural Resources	AEER EUR-ACE® WA	2010-2015 2012-2015
14.	280102	INT	Safety of Technological Processes and Productions	AEER EUR-ACE® WA	2010-2015 2012-2015
15.	120302	INT	Land Cadastre	AEER EUR-ACE® WA	2010-2015 2012-2015
	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
	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

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
	Ufa State Petroleum Technological University				
1.	130504	INT	Oil and Gas Drilling	AEER EUR-ACE® WA	2007-2012 2012
2.	130603	INT	Oil and Gas Processing Equipment	AEER EUR-ACE® WA	2007-2012 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 2012-2013
6.	130602	INT	Oil and Gas Fields Machinery and Equipment	AEER EUR-ACE® WA	2008-2013 2012-2013
7.	130501	INT	Design, Construction and Operation of Gas and Oil Pipelines and Storage Facilities	AEER EUR-ACE® WA	2009-2014 2012-2014
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

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

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LIST OF AEER ACCREDITED PROGRAMMES

	Programme Code	Qualification	Programme Name	Certificate	Accreditation Period
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 01.06.2017)

	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 01.06.2017)

	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 01.06.2017)

	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 01.06.2017)

	Programme Code	Qualification	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

LIST OF AEER ACCREDITED PROGRAMMES

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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 Espaсa – 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

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Association for Engineering Education of Russia

is re-authorized

from 31 June 2015
to 31 December 2019

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

Brussels, 23 June 2015

EUR-ACE label awards: Authorization Period

Status: 23 June 2015

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

ENGINEERING EDUCATION

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