

19. Efimov V.S., Lapteva A.V. Budushchee vysshei shkoly v Rossii: ekspertnyi vzglyad: for-sait-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_Vyssha-ya_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 deyatelnosti: 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 – halbiertes 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 sdeleno v rabo-chem 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



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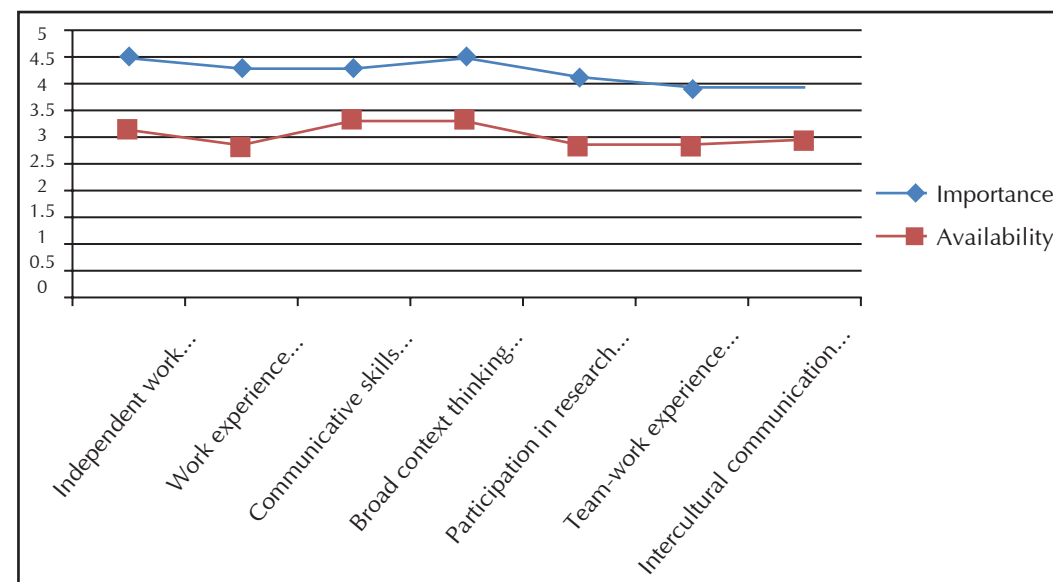
international project to study the possibility to apply international assessment of higher education learning outcomes for students studying in diverse language, cultural and infrastructural educational environments (AHELO (Assessment of Higher Education Learning Outcomes), 2008-2012).

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 plans¹. 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

¹The 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]. Rossiyskaya 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 [Elektronnyy 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][Elektronnyy 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] [Elektronnyy 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] [Elektronnyy 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. potrebnosti 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][Elektronnyy 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.).