

## ENGINEERING COMPETENCES OF UNIVERSITY GRADUATES: VIEW OF EMPLOYERS AND YOUNG SPECIALISTS

Inna Krutko, Natalia Popova  
Ural Federal University, Russia  
busygina@rambler.ru, n.v.popova@urfu.ru

**Abstract.** Young professionals are a product that higher education supplies to the labor market. Employers should provide opportunities for them to apply their professional knowledge in their future work places. Today the labor market in Russia is characterized by spontaneity and lack of balance. There are no scientifically based forecast estimates of staffing needs. For this reason, university graduates cannot always work in their specialty. Some of them find themselves unemployed. Other young professionals go into commerce or the service sector, losing their university qualifications. The novelty of the research lies in the study of engineering competencies on the part of employers and the young specialist of the plant, as well as in highlighting the content of key engineering competence and the conditions for formation. The problem gets worse in a situation of turbulence, when the employer's requests are incomprehensible, the educational institution is inert, and the young people themselves feel like superheroes. The authors used the following methods: questioning the views of respondents from the outside: university students already working at an industrial enterprise; working young professionals; employer representatives; psychological testing of young workers. Young people who have graduated or are continuing their studies claim that their level of education is higher than the work required. The employer, on the other hand, points to a clear excess of theoretical knowledge among young workers and an inadequacy of engineering competencies. Testing of young specialists in engineering specialties showed that it is possible to single out "key systemic competence", which testifies good potential opportunities among young specialists, which include the ability for self-development and interaction, the ability to independently find information; working capacity; developed thinking; emotional stability; responsibility; leadership. Professional and social competence are linked. This allows young people to successfully adapt in the team and identify themselves with the enterprise. Employers assess such young people as "sufficiently prepared for work". Based on the results of the study, the authors modeled the training program "School for Young Specialists", which is being implemented at industrial enterprises of the Sverdlovsk Region in Russia.

**Keywords:** professional qualifications, young specialist, engineering competencies, competitiveness.

### Introduction

The level of development of employees' competencies depends on their professional training received at the relevant university. The qualifications of workers are often described in terms of formal quantitative indicators. The number of people with higher education is such an indicator. Note that the number of holders of diplomas does not indicate the real quality of education. The owner's diploma does not guarantee that he has formed competencies. At the same time, scientists understand that competence is the ability to successfully solve complex problems in a given situation by mobilizing various psychological resources [1].

The competence-based approach is used in the development of state educational standards of the third generation in Russia. Curriculum content is not the main outcome when these standards are developed. The qualification of the graduate, his readiness to perform practical functions is this result. Graduates of institutions of higher professional education of an engineering profile must possess basic and engineering, and technical competencies. They contribute to the development of modern science-intensive technologies and the implementation of scientifically grounded technical projects, the formation of national innovation systems. Competence is more than having the knowledge or skills required to accomplish a specific task. Engineering competence means that an engineer performing a production process consistently integrates knowledge, skills and personal qualities into daily practice in order to meet established performance standards [2]. The experience of the authors in the personnel services of industrial enterprises allows us to assert that today university graduates who have received education in the specialties required by the plant are in great demand: the reason is both in demography and in the fashion for professions of a lighter profile [3].

In order to increase labor productivity, the rational use of the abilities of each employee becomes important in these conditions. Enterprises will pay more attention to the efficient use of the capabilities of each employee, adaptation in the workplace and a continuous training system in the enterprise.

Young specialists are the main product supplied by higher education to the labor market. Even during the period of study, employers should provide them with opportunities for effective application of their professional knowledge in the field of future work, when students are studying at a university. It is known that a model of behavior, formed mainly by an educational institution, influences the professional formation and development of young workers [4]. The specialist needs to quickly navigate in modern production. He is forced to constantly improve his qualifications, and often master new related professions in order to remain competitive. Today, in many Western firms, the emphasis is shifting to the training of a wide-profile specialist who is able to change rapidly depending on changes in market conditions and a corresponding change in the very nature of work. For example, E.F. Seer, analyzing the situation in West German firms, writes that the training of new workers, “able to adapt to dynamic production, easily move from one type of labor to another, with the skills necessary for a wide range of professions” is becoming important [5].

S.Chillas, A.Marks, L.Galloway examine a particular type of internship in the ICT sector, namely placements incorporated in degree education. The findings suggest that while internships can enhance employability and indeed be a mechanism for accessing permanent jobs, more often, instead of ‘learning to labour’, interns are expected to be productive workers [6].

E.Smith, P. White present some key findings from a project funded by the Nuffield Foundation that examined patterns of education and employment among STEM graduates in the UK. Five large-scale secondary datasets – comprising administrative, survey, cross-sectional and longitudinal data—were analysed in order to provide the most comprehensive account possible. The findings suggest that there is no overall shortage of STEM graduates, but there is considerable variation in the career outcomes and trajectories of different groups [7].

Thus, we need to know the answers to the following questions. What competencies should a young specialist have? What kind of training should a university graduate have? What competencies should an engineering worker have?

## Materials and methods

We conducted a survey of respondents. They are:

- university students who already work at an industrial enterprise;
- young specialists, whose work experience is up to 3 years;
- employers of one of the largest metallurgical enterprises in Russia.

We conducted testing using the following methods: Brief selection test (BST), R. Cattell’s 16-factor personality questionnaire, K. Thomas – Kilman’s methodology “Types of behavior in a conflict situation”, “Thinking style questionnaire”, a method for studying the level of subjective control (LSC). We analyzed the data obtained and modeled the Young Professionals School program based on these results. This program is being implemented at industrial enterprises of the Sverdlovsk region. The main research was carried out in 2020 on the basis of a large metallurgical enterprise in Yekaterinburg. The study involved 88 people.

## Results and discussion

The results of the expert interviews with managers of young specialists in engineering specialties showed what competencies have already been formed, and the competencies that young engineers working at the plant should have (Table 1).

Table 1

### List of the most significant competencies of young engineers in the opinion of managers

Rating	Available competences	Required competencies
1	Good team contacts	Engineering excellence
2	Rapid assimilation of new knowledge	Productive teamwork
3	Ability to express your thoughts	Effective use of time
4	Effective use of time	Self management
5	Analytic skills	Control yourself and work processes
6	Drawing up documentation	Rapid assimilation of new knowledge
7	Theoretical knowledge in the specialty	Ability to express your thoughts

Obviously, the lists coincide only partially, and managers – employers point to a number of competencies that young engineers who have come to the enterprise do not possess.

The same expert interview made it possible to select the most promising young specialists ( $n = 23$ ), according to the criterion of “subjective opinion of managers-employers”. In general, employers assess such specialists as “sufficiently prepared for the implementation of labor activities”. Among these young specialists were those who worked at the plant for less than 3 years, as well as university students who combined work with study at an industrial enterprise.

The results of a survey of promising young specialists and their leaders showed that the majority of young specialists (69.6%) work in their specialty received at a university. Almost all of them claimed that their level of education was higher than the job required. Leaders point to the redundancy of the knowledge component and the lack of engineering competencies among young people. In the initial period of their labor activity, more than half of young specialists, to one degree or another, felt a contradiction between theoretical training in an educational institution and the skills of practical use of the knowledge gained at work.

We asked the survey participants to formulate professional competencies that a modern promising young plant specialist should possess. According to the respondents, a young engineering specialist should have the following professional competencies: dedication, energy, striving for self-development in professional activity, the ability to think ahead, a creative approach to solving production problems, the presence of leadership potential, the ability to perceive new things in work, self-control, enthusiasm. The majority of young specialists assess their compliance with this ideal rather highly, namely, three quarters of the respondents believe that “in our country, the majority are like that”.

We formed a control group of young specialists ( $n = 23$ ), which is quite enough for in-depth research. Experts recognized them as less successful and promising. Their survey showed that they state doubts about the choice of a place of work, profession and admit the difficulties in adaptation at the plant. The test results of this group were used to prove the significance of differences from the experimental one. The results of the study are presented in Table 2.

Table 2

Comparative results of testing young specialists

Groups of young professionals	BST, average score	Cattell Scales: C - emotional stability; E – subordination; G – normative; N - straightness; C-E-G-N, walls;	Thomas-Kilman test, results by scales, % of the sample	LSC technique: scales Io/Id/In/Ip walls
“Promising”	25,6	9 – 6 – 7 – 11	Collaboration 59 Compromise 44 Assignment 12	4/6/3/6
“Ordinary”	18,9	4 – 5 – 4 – 5	Collaboration 15 Rivalry 34 Compromise 11 Assignment 21	4/3/4/3

The average results obtained from the Brief Orientation Test are indicative. The analysis of indicators on the scales showed that the “verbal factor”, “logical factor”, “spatial-symbolic factor” have higher values in the group of “promising” young specialists. This indicates the predominance of their flexibility of thinking, operations of abstraction and semantic interpretation, high switchability from one type of activity to another without loss of effectiveness. This group shows at a reliable level high speed and accuracy of perception, distribution and concentration of attention, good spatial orientation.

We used sample scales of interest for our study. These are “emotional stability” - C, “subordination-dominance” - E, “normative behavior” - G, “straightforwardness-diplomacy” - N in the Cattell test 16PF. Young specialists of the “promising” group are characterized by emotional stability, considerable consistency; calmness in most situations, stability in interests, some rigidity; generally, reality-oriented. On the scale of subordination of significant ones, we did not reveal any differences. In both groups there

are independent, stubborn, assertive young people with varying degrees of conflict. Aggressiveness, refusal to recognize external power, a tendency to authoritarian behavior are manifested mainly in the group of “ordinary”. As regards the parameter of normative behavior, the differences are reliable: “promising” respondents show greater conscientiousness, responsibility, stability, poise, and persistence than “ordinary” young specialists. They have a developed sense of duty and responsibility, conscious observance of generally accepted moral rules and norms, persistence in achieving goals, and a business orientation. In terms of straightforwardness, young specialists also stand out at a significant level: they are diplomatic in communication, emotionally restrained, careful and even show cunning, they know how to find a way out of difficult situations, and are prudent.

The test results on the subjective control questionnaire show significant differences in both groups. Promising young professionals believe that most important events in their lives are the result of their own actions, that they can control them. They feel their own responsibility for these events and for the way their life in general develops. The Id scale shows that they believe that young specialists themselves have achieved all the good that was and is in their life, and that they are able to successfully achieve their goals in the future. They are not inclined to blame themselves for various troubles and suffering. The obtained IP indicators also indicate that these young specialists consider their actions to be an important factor in organizing their own production activities, developing relationships in the team, their promotion, etc. Thus, promising young specialists are mainly internally, i.e. take credit for their success and take responsibility for what happens in their professional lives. Differences with the group of “ordinary” young specialists show a significant level.

To test the significance of the differences in the variables, the Student’s t-test was chosen, for which the analysis of the normality of the distribution was carried out. Significant results of comparing the average indicators for tests for two groups of respondents are presented below.

Table 3

#### Differences among young professionals (Student’s *t*-test)

Factors	Promising young professionals		Conventional young specialists	
	Average values	Standard deviation	Average values	Standard deviation
Verbal-logical factor	5.0**	0.63	4.8**	0.58
Self-activity/thoughts	4.3***	0.69	4.8***	0.65
Normative behavior	4.4***	0.63	4.8***	0.50
Attainment	4.4***	0.75	4.9***	0.60
Emotional resilience	4.9**	0.59	4.7**	0.67
Security/Personal	5.0***	0.69	5.2***	0.60
Externality of the locus of control	3.9**	0.64	4.1**	0.77

Note:

\*: differences are significant at  $p < 0.05$ ;

\*\*: differences are significant at  $p < 0.01$ ;

\*\*\*: differences are significant at  $p < 0.001$ .

Differences were also revealed in a number of values of promising young specialists (hedonism, achievable type, etc.). Differences with the group of “ordinary” Moldovan specialists show a reliable level.

The study showed that “promising” young specialists showed such qualities as developed technical and logical thinking, organization, initiative, good communication skills and ability to interact, some of them had leadership potential. A higher level of aspirations, the desire to achieve success and high results in life were also characteristic of them.

The results of the factor analysis obtained by the group of “promising” young specialists showed a single leading factor. We tend to call this systemic factor the “key engineering competence” of university graduates of various engineering specialties. Indicators (learning ability, the ability to self-development, the ability to independently find information; high efficiency; emotional stability; leadership; ability to interact, internality) are internal indicators and form a complex construct. The severity of this factor

indicates the good potential of a young specialist who comes to the enterprise. The second factor, which we have identified as a result of the analysis, is weaker. These are sufficiently developed “soft” competencies; it can be stated that professional and social competence are welded into a double construct.

The space of acquired competencies is organized between the two identified factors. Here, the two main structuring factors are “engineering core competency” (F1 axis) and “social competence” (F2 axis). The first axis ranks according to the degree of professional skill, the ability to generate, evaluate ‘own and other people’s ideas, and effectively interact. The emphasis is on the practical application of engineering skills, and theoretical knowledge of the specialty is not a differentiating factor. The second axis characterizes the distribution of respondents in terms of “soft competencies,” such as the ability to sell their ideas, present work results, and persistence in achieving goals. The presented results of “hard and soft” competencies form a kind of classification: in practice, competencies are distinguished, which form the following blocks:

- “professional dynamism”
- “focus on results”
- “willingness to work collectively”
- “cognitive skills”.

The above findings echo the results of similar studies, according to which, at Russian enterprises, the most in demand are engineering competencies, such as readiness for effective behavior in a competitive environment under stressful conditions; the ability to act and make responsible decisions in non-standard and uncertain situations; striving for continuous self-education and improvement of qualifications [8].

Forming the designated attitudes among university graduates who come to an industrial enterprise facilitates the course of the “conflict of entering the organization” and the processes of adaptation in the work collective, the assimilation of social norms and values of corporate culture. The School of Young Professionals program solves this problem. The main idea of such training is the formation of key competencies of a young specialist, who successfully adapts to the conditions of professional activity at the plant. Four training modules are included in the program. They (modules) consistently build up the required competencies: professional self-determination of a young specialist, professional interactions in the work of a young specialist, professionalism and engineering competence, a promising young specialist. We have the opportunity to leverage and develop a range of creative learning and teaching resources that bring modules to life once the fundamentals of engineering competency are incorporated into the program. The objectives of the training are acquaintance with theories at the heart of engineering solutions at the plant, generalization of best practices and engineering solutions in metallurgy, involving young specialists in research activities, learning through modeling game solutions, epistemic (research cognitive) imprinting, project activities in which young specialists develop management solutions for engineering problems.

Thus, the development of engineering competencies of young specialists is the awakening of a deep interest in the profession, knowledge of oneself in it, the development of curiosity and a keen mind, a three-dimensional look and professional thinking, the formation of critical thinking, constructive interaction, the search and application of additional information, cooperation, development design solutions.

## Conclusions

1. Competence-based approach allows to shift the main emphasis of professional education on the quality and efficiency of work. Engineering competencies of a university graduate, as well as a young specialist, being evaluated and tested at the workplace, show “incompetence”.
2. The research shows that “promising” young specialists at a reliable level demonstrate differences with “ordinary” young specialists in cognitive abilities, indicators of emotional intelligence (emotional stability, subordination, normative behavior, straightforwardness); they are oriented towards cooperation and compromise and have an internal locus of control, that is, they see themselves as the cause of professional success and failure.

3. A single construct “key engineering competence” of young specialists of various engineering specialties includes most of the discovered skills, qualities and competencies. This construct is associated with the “soft” competence factor. We can argue that professional and social competence are welded into a double construct and it is its presence and development that ensures efficiency in the technical profession.
4. Content blocks are immanently part of the selected construct. These are professional dynamism, focus on results, readiness for teamwork, cognitive competencies. These results made it possible to build and successfully implement a program for young specialists in metallurgy enterprises that develops engineering competencies.

## References

- [1] Багдасарьян Н.Г., Гаврилина Е.А. Еще раз о компетенциях выпускников инженерных программ, или концепт культуры в компетенциях инженеров (Once again about the competencies of engineering graduates, or the concept of culture in the competencies of engineers). Высшее образование в России: Higher Education in Russia. 2010, No. 6. pp. 23-28 (In Russian)
- [2] Попова Н. В. Какой выпускник вуза востребован на современном промышленном предприятии?( Which university graduate is in demand at a modern industrial enterprise?). Гуманитарное образование в креативно-антропологическом измерении: сборник научных статей 12-й Всероссийской научно-практической конференции, Екатеринбург, 19-20 ноября 2015 г./науч.ред. С. З. Гончаров. Екатеринбург: Издательский Дом «Ажур» (Humanities education in the creative-anthropological dimension: collection of scientific articles of the 12th All-Russian scientific-practical conference, Yekaterinburg, November 19-20, 2015/scientific ed. S. Z. Goncharov. Yekaterinburg: Publishing House “Azhur”), 2015, pp. 82-90 (In Russian)
- [3] Krutko I.S., Masalimova A.R., Ponomarev A.V., Popova N.V., Senuk Z.V. Innovations in university education in the context of modern global challenges. Proceeding of the 5th International Conference on Advances in Education and Social Sciences, October 21-23, 2019, Istanbul, Turkey, pp. 199-201
- [4] Зазыкин В.Г., Чернышев А. П. Акмеологические проблемы профессионализма (Acmeological problems of professionalism). Moscow: НИИО, 1993, 47 p. (in Russian).
- [5] Зеер Э.Ф. Модернизация профессионального образования в ФРГ (Modernization of vocational education in Germany). Педагогика: Pedagogy, 1993, No. 4, pp.106-110 (in Russian).
- [6] Chillias S., Marks A., Galloway L. Learning to labour: an evaluation of internships and employability in the ICT sector // New Technology, Work and Employment. 2015. Т. 30. no. 1. pp. 1-15.
- [7] Smith E., White P. Where Do All the STEM Graduates Go? Higher Education, the Labour Market and Career Trajectories in the UK. Journal of Science Education and Technology. 2019. Т. 28. no. 1. pp. 26-40.
- [8] Ендовицкий Д.А., Титов В.Т. Практика модернизации. Компетенции и востребованность выпускника: кто нужен работодателю? (Modernization practice. Competencies and demand for a graduate: who does an employer need?). Высшее образование в России: Higher Education in Russia, 2011, No. 6, pp. 3-9 (In Russian).