

COMPETENCES OF FUTURE ENGINEERS

Irina I. Kharchenko¹, Natalya G. Nizovkina²

¹Institute of Economics and Industrial Engineering Siberian Branch
of the Russian Academy of Sciences, Novosibirsk, Russia,
e-mail: I.Kharchen@gmail.com

ORCID ID: 0000-0001-5348-0587

²Novosibirsk State Technical University, Novosibirsk, Russia,
e-mail: nizovkina@ngs.ru

ORCID ID: 0000-0002-3947-0849

Abstract. The research is directed, on the one hand, to prove the additional professional competences in innovations and business when training engineers in modern conditions, on the other hand, - to analyze educational behavior and professional competences of university students. The paper discusses that the quality of training engineering students can be improved not only at the expense of material base of higher educational institutions and contribution of employers (the called positive changes of training conditions are confirmed by our empirical data), but also due to the students' set of knowledge and skills - professional, technical, innovative, research, economic and business. Also, it can be done by the creation of motivation system to the professional and working activity. The originality of the used approach and represented results is, in the fact, that these conclusions are based on the data analysis of the mass sociological survey of university senior students in Novosibirsk region (in 2016 2583 sociological questionnaires were gathered) and are confirmed by the case from the real practice of big engineering university like Novosibirsk State Technical University (NSTU). Method of comparison of three groups of the interviewed students is applied in the research: engineering students of NSTU, all engineering students, all students of the sample.

The material base of the most engineering departments in NSTU was greatly enriched in recent years, including due to the cooperation with business. However, there are problems of harmonization of professional competences among students.

When interacting with enterprises students are absolutely not introduced to their "economic world". They do not analyze the organizational or administrative tasks relating to production, logistics, quality, and information systems. They do not define the marketing demands, which could lead to the realization of the project on creation of an innovative product or service.

These practical tasks could become the basis for the competence formation

to establish a new venture or activity on all aspects, including commercial, financial, economic and legal ones. Apart from the traditional scientific and technical training, the modern engineers should be trained in the context of innovative and market environment.

On the case of NSTU which has different innovative structures (research centers, centers of modern technologies, scientific-educational centers, scientific laboratories), it is shown that this factor favorably affects the results of professional education. As it was succeeded to find out, NSTU students-engineers in general are more prepared for work on the specialty (in comparison with average data). Also these students slightly differ from all interrogated young people because they are more interested in innovations. However many contradictions remain. Most of students of final years of this university (on a self-assessment) are lack of practical skills necessary in engineering work and the more so for business, they assessed relatively low organizational and managerial competencies and not so remarkable innovative ones. Author's experience in teaching and executed observations give the grounds to consider that the expected strong motivation of entrepreneurship among graduates is not formed. At the same time the career of businessman seems attractive to 44% of the interviewed students of engineering specialties. Authors of the article are convinced that these issues occur because of using an active learning methodology on the basis of the large industrial enterprises where students-engineers fall into a rigid hierarchical system. So they cannot get beyond the influence of large well-established structures and standard thinking.

We draw conclusion about the insufficiency of measures and processes, which need to be applied in order to unite skills and habits in design, technique, commercial, marketing and financial areas of future engineers for transforming ideas into reality.

Keywords: professional competences, students, motivation, innovation, engineering, entrepreneurship

Introduction

In the context of modernization process in the higher education system of modern Russia, the important task is the formation of the set of necessary competences of students. On the other hand, engineer's work links closely with innovations in the modern economy. Engineer should know the basic concepts of management to be able to make better decisions for technological innovation processes. However, the main thing that engineers can do using their professional knowledge is to work for the development of enterprises. The modern economy requires innovative approaches to the enterprise development (Henry C., Hill F.M., Leitch C.M., 2004). For these

purpose engineer should be able to conduct the joint scientific research, transfer knowledge and technologies, and assist in the establishment of new activities and jobs. And these qualities must be formed while learning.

Objectives of the study

The aim of our research is to show the need to include additional requirements for the formation of innovative, economic and business competencies, and their harmonization in engineer training nowadays. The analysis of educational behavior and professional competences of students was a research task on the data of mass poll.

Methodology

For achievement of the research goal the data of monitoring sociological survey collected by IEIE SB RAS in 2016 are attracted. The database contains: 4670 questionnaires of students of graduate and pre graduate courses of higher education institutions and colleges (subsample of higher education institutions is 2583, including 360 questionnaires of NGTU students), objective information about the educational institutions included in the sample (38 units), interviews with their representatives (31 people). For the analysis in dynamics comparable data of the sociological surveys of students conducted by IEIE SB RAS in 2001 and in 2007 are used. In the sample the main professional groups of training in higher education institutions and colleges of the Novosibirsk region are presented.

We do the study on the data of the mass sociological survey and also considered NSTU (and especially the Department of Mechanical Engineering) as an example from real practical activities (Nizovkina N.G., 2014; Nizovkina N.G., Kharchenko I.I., 2017; Nikitin Yu.V., Surnina T.Yu., 2017).

In this case the method of the long included observation was used. Method of comparison of three groups of the interviewed students is applied in the research: 1) engineering students of NSTU; 2) all engineering students; 3) all students of the sample.

Findings

The data of 3 “waves” of questionnaire survey (from 2001 to 2016 and from 2007 to 2016) showed that students became more satisfied with the material conditions of the educational process. Students of technical specialties noted the increased availability of new equipment used in their profession. The students have increased interest in opening their own business, but demonstrate the lack of skills for this. In case of need to continue education (after graduating from the university) every second student-engineer plans to study economics, finance, business or management. Among the future engineers, the percentage of positive responses to the questions about the obtained set of "engineering competencies" is at the level of 65% to 82%.

But in terms of such competences as “to find creative solutions” (56%) and “organizational skills” (41.5%) students-engineers fall behind "average" asked students. They are also behind in terms of such skills as "the ability to work in a team" and "the practical experience". On the contrary the engineers outdo other students in terms of professional competencies (see the Table).

Despite some positive developments the low level of practical skills among all students is considered as the remarkable problem (see the Table).

Table - Competences and interest of students to work in research sphere, in innovative economy, to organize their own business (Novosibirsk region, 2016 year, N = 2583)

Sociological indicators, % of responses within the group	Engineering students, NSTU	All engineering students	All interviewed students
<i>A comparison of the replies (optional) for the pair of questions: "what requirements, do you think, are typically imposed by employers to graduates of your specialty?" and "which of these requirements, will you be able to meet?":</i>			
- a good knowledge of facts, terms and theory of the profession: "imposed"/"match"	38,8 / 35,4	33,9 / 25,3	34,3 / 26,4
- the specific practical skills: "imposed"/"match"	74,2 / 34,0	61,7 / 29,1	59,0 / 28,1
- the ability to learn quickly and apply the recent achievements of progress: "imposed"/"match"	51,7 / 51,7	43,5 / 44,1	42,8 / 40,8
- the ability to generate (come up with) new ideas, set new tasks: "imposed"/"match"	28,2 / 26,8	20,8 / 21,7	25,0 / 23,7
- the initiative, the ability to implement new ideas: "imposed"/"match"	27,3 / 29,2	20,5 / 23,1	25,5 / 26,3
<i>Relevance to the research work:</i>			
- participation in the research work currently: "engaged"/"do not participate, but would like to"	40,2 / 34,0	24,8 / 36,0	36,3 / 29,6
- would like to be engaged in research work after graduation: "Yes, definitely"/"Yes, under certain conditions"	18,7 / 17,7	11,8 / 11,1	16,4 / 10,6
<i>Attitude to a new type of economy (innovative):</i>			
- "would like to work in a new type of economy"/"not interested"	59,0 / 41,0	45,4 / 54,6	46,9 / 53,1
- could demonstrate "non-standard creative thinking, the ability to innovate" in the case of joining the	25,6	24,4	26,7

team to achieve the goal, and to solve the problem			
The following responses to the question about the possibility to be trained on a new equipment were received: " training to work on new equipment in the University" + "in the resource center"/"training only on an out-of-date equipment"	35,1 / 30,3	29,2 / 30,9	23,9 / 20,6
<i>Attitude to the possibility of business ownership:</i>			
-could demonstrate such qualities as "initiative and experience in business» in the case of joining the team to achieve the goal, and to solve the problem	11,6	7,5	9,2
- would prefer to start a business when thinking about future employment	32,1	30,7	30,0
- consider the business ownership as a suitable career	44,5	39,2	36,9
Total, students	209	994	2583

Demanded economic competences of future engineers and the applied techniques of their formation

Yu.V. Nikitin with coauthor describe the results of the three years training programs for enterprises of the defense industry complex (a practice-oriented approach in education) (Nikitin Yu.V., Surnina T.Yu., 2017). The cited article describes a positive experience in the Novosibirsk region based on the chain of "School - Technical College-University-Enterprise". Students participating in the project on request of the enterprise have to be ready to work as a designer, engineer, researcher and developer of manufacturing technological processes. The most important stage in the development of educational modules is the alignment of professional competencies. The teaching methods and techniques, the ability to communicate with industrial enterprises and research organizations provide a positive result. But our long experience of research, teaching and observation of training process of engineering students indicates that technical issues are not taught in conjunction with the economic, organizational and managerial problems of industrial enterprise.

The radical education project (Worldwide CDIO Initiative) proved that it yields good results for students such as: development of professional competences while passing through the stages of engineering activity (conceive-design-implement-operate), education in the context of practice, personal and interpersonal competences, skills of team work for

achievement of the planned result and others. But it does not cause cultural changes among students in training, in overcoming the fear of creating new businesses or activities, and in realizing that they are able to succeed, while introducing their ideas.

In our opinion participation in civil and community initiatives and in the economic development of the territory gives good experience to future engineers. The students were asked the following question: "Do you feel yourself involved in the business development of area (city, district, village, where you live or study) and in the improvement of the human condition, if Yes, in what extend?". Only 19.7% of the students said "fully" or "partial" about their involvement, 27% of responders said "they do not feel the involvement, but would like to" and 32.8% of responders claimed "they have other interests" and others don't know. As we can see, more than every fourth of responders need a help to be engaged in this noble activity. Even if there are the necessary innovative institutions, such as incubators, and new methodologies, such as innovative designs and practices in enterprises-partners, the graduates also need support measures to be engaged in a system of cultural, social and economic development of enterprise and the territory.

Using the method of critical thinking development allowed to reveal that students-engineers are interested in the following issues: 1) Functional tasks in business activity. 2) The need to share the part of economic effect in the production of new products with the buyers. 3) The assessment of budgets and economic efficiency in the context of uncertainty. 4) The definition of efficiency criteria and methods for determining prices for new products. But the used training methods not always give answers to the questions posed (Souitaris V., Zerbinati S, Al-Laham A., 2007). For example the technical calculations of estimated budgets (Behrens W., Hawranek P.M., 1991) use a virtual information, and this remoteness from reality does not bring stable skills.

Under the existing educational standards for engineering training the attention is not paid to development and promotion of entrepreneur inclinations. And what is more that practices of training being applied on the basis of large industrial enterprises with a rigid hierarchical system restrict students in their imaginative and prompt actions.

The material base of the Department allows teaching through action, not imitating them. For the formation of entrepreneur behavior (initiative, interdisciplinary skills, autonomy, self-organization and ability to organize others, interpersonal skills, intuition, tolerance) the Department must put students in the problematic situation which does not have an immediate solution. However this technique is very difficult.

Discussion

The creative thinking is necessary for the society development. It is based on the assessment of cultural, social, political, and ethical aspects regarding new technological decisions which will be made by the new society. The young engineers should take an active part in these processes. In addition to the traditional scientific and technical training, the modern engineer must be formed under conditions of real innovation and market. The study shows that students-engineers are interested in new opportunities offered by the market economy. But the majority of interrogated students (about three-quarters) did not see the demand for innovative competencies related to the creation of a new product in a modern economy (see the Table). About one half of future engineers are characterized by strong interest in business, and it creates a base for the needs of the present and future economic and business competencies. In addition, it is necessary to develop and promote innovative and research competences of students. The main problem of current education situation is the practice mainly on large enterprises and lack of entrepreneurship practice. All these need to be complemented by any working business motivating methods and practices so students can learn to innovate, to create economic and social wealth in society based on entrepreneurship where the risky, challenging and imaginative solutions play an important role.

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