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Complex Engineering Training as a Key Element of Higher Technical Education Development

Nataliya Maksimova*, Yuliya Zeremskaya

Tomsk Polytechnic University, Tomsk, 634050, Russia

Abstract

Key aspects of higher education development are observed. Problems with scientific knowledge promotion are investigated. Important society living environments influenced on youth involvement in science, innovation and business activity are emphasized. The survey was carried out in the Tomsk Polytechnic University. The students' survey findings showed the students' attitude to business activity and Foresight strategy. A new technical students' training model is suggested. Due to this model students can carry out complex business activity based on problem-oriented training on Foresight level. The aim of this model implementation is a training of competitive specialist with innovative way of thinking who has knowledge not only in the field of fundamental science but also in the field of management and business activity. The application importance of Foresight strategy and international education systems in future engineers training was justified. Results of engineers' training in technical universities were presented and planned competences were formulated.

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Keywords: Complex engineering; training model; entrepreneurial competence; Foresight strategy; innovative activity

1. Introduction

An important factor of successful country development is active and goal-oriented youth training. Effectively working system of higher education is reflected in the nearest future. Economics and society always need qualified engineers and researchers. Higher technical education development is a timely necessary requirement for a modern constant changing world. The key directions of higher education modernization are the following:

* Corresponding author. Tel.: +7 913 820 2366
E-mail address: nata8720@mail.ru

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1. Development of organizational training forms;
2. Designing of new education technologies and models;
3. Monitoring and assessment of education level;
4. Inter-university cooperation;
5. Academic mobility of lecturers and students;
6. Commitment to innovation;
7. Development of research and practice oriented universities' area.

Another key element in higher technical education development is training of engineers ready to complex innovative engineering activities under the conditions of constant technical systems, economics and society development. Innovative way of country development should be accompanied by qualitative training not only engineers with fundamental knowledge but researchers of new generation and multifunctional specialists meeting worldwide trends.

Under current conditions it is not enough to perform only professional duties. It is obvious that today's engineers should combine their professional duties with innovative, entrepreneurial and managerial ones. University graduates should have up-to-date knowledge. High requirements to university graduates show the necessity in higher technical education system modernization and development. Advanced professional education is directed to the development of inborn aptitude to get knowledge and transition from conceptual reality understanding to solving engineering, social, managerial, technological tasks (Luchnikov, 2013).

2. Goals of research

Specialist training and upbringing ready for a complex engineering activity is important today as engineers are considered to be a key element of country development. Thus, there is a problem which must be solved. The problem is how the specialists' training system should be changed in technical university in order to teach future specialist not only research activities but also innovative and entrepreneurial activities. To increase and to take advantage of intellectual resources as usual is impossible. Traditional organization of group learning is ineffective today. Thus, there is a need to use up-to-date teaching approaches and nonstandard teaching models. The following objects of research are set:

- justify the need for popularization of scientific knowledge and youth involving in innovative and engineering activity;
- bring engineers' training results up-to-date in technical universities;
- justify the need for innovative and entrepreneurial competence developing;
- find out a complex of teaching methods, methodologies, instructional devices for training engineering activity;
- develop teaching models in technical universities which help future university graduates to carry out engineering activity.

A complex engineering activity of future engineers is understood as a combination of fundamental sciences and professional duties with entrepreneurial, managerial competences; an innovative way of thinking; competitive ability in global community and foresight competences in engineering system development.

3. Steps of the study

The study was carried out in Tomsk Polytechnic University. Students' poll was the first step of study. Having examined students' answers about entrepreneurship, its development and possibilities, the following conclusions can be made:

- 7% of pollees have already carried on business;
- 33% of pollees are going to run a business;
- 41% of pollees are not interested in doing business;
- 26% of pollees neither agree nor disagree;
- 92% of pollees consider that business activity should be developed in Russia;
- 30% of pollees are going to do business in the sphere of trade; 23% of pollees - in the sphere of consumer services and only 8% of pollees in the sphere of knowledge-intensive industry;

- 61% of pollees consider that the lack of knowledge and experience does not allow them doing business;
- some pollees are interested in business activity because of financial independence (52%), decision-making discretion (63%), large income obtaining (28%), sustainable future (8%), meetings with interesting people (25%), career growth (18%), high business risk (47%).

The second step of the study is connected with problem analysis of youth involvement in innovative and entrepreneurial activity. It is necessary to enhance the prestige of research activity and to explain the importance of innovative technology development activities. The system evolution of the popularization of research and technology work and youth involvement in innovative activity should be at work. Interrelations of innovative and business activities should be noted. Today the innovative activity in Russia is connected with the formation of new business culture. The idea of innovative activity as a main functional business characteristic was given by Joseph Schumpeter. He wrote about an entrepreneur carried out reorganization of economic life on the basis of private viability. The aim of business activity is production efficiency improvement, creation of a rival product, which can bring extra profit. Any innovation activity is a business one as it is independent and connected with entrepreneur's readiness to accept risk for realization of a new project (Alekseeva, 2010). The key spheres influenced on youth involvement in research, innovative and entrepreneurial activities can be emphasized (Fig.1).

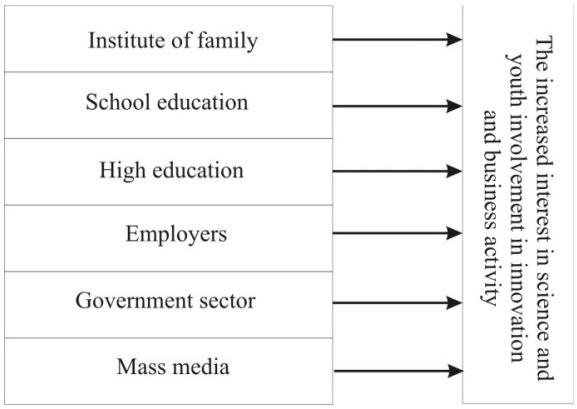

Fig. 1. Spheres influencing on youth involvement in science, innovation and business

Elucidative events as a part of secondary education curriculum will be effective. Pupils should get interested in scientific activities at school. Here a school teacher plays a very important role as he/she communicates with a pupil. Investigations of personal and psychological characteristics of pupils, students, teachers, educators done at secondary and high institutions show that, on the one hand, young generation has a great potential and creative abilities and, on the other hand, it has a weak realization of this potential in the majority of educational institutions. Qualitative youth training and upbringing is an investment in country's future.

Teaching process should be directed on the activization of training and cognitive activities. Individual student's characteristics such as character, interests and preferences should be taken into account. Active methods of individual and group cognitive activity should be used. Training process should be oriented not only on training, but also on the development of intellectual, professional, creative abilities and abilities for self-study. Basic psychological training concepts such as a principle of "training on a high level of difficulty", active individual and group cognitive activity should be realized in training process. Moreover, practical group activities such as creation of different projects, interactive communication, excursions to factories, participation in different competitions and science conferences, visiting innovative forums and exhibitions must be carried out (Sokolova, 2013).

Family also plays an important role in the system of youth upbringing, development and personal identity. The development of creativeness and intellect also depends on family. Parents can help a child in personal identity through communication and participation in child's life. Grown-ups should motivate children for developing and cognitive activity. Cooperation of parents and children such as communication, explanation of events, discussion of

the future and its planning is necessary. This is, of course, an ideal system of family upbringing, but it is difficult to follow this system as there are many constraining factors.

The interest to innovative and business activities can be increased by an active cooperation of universities and employers. Scientists and production workers, the usage of scientific laboratories and production capabilities should be involved in the educational process. Innovative, science-based companies are interested in high qualified employees. Thus, they should take an active part in the training process of engineers, inventors and scientists. The employers can help students in professional orientation and in making a right choice of a future profession. Therefore, the cooperation of universities and employers is effective and mutually beneficial.

Under conditions of transmission to innovative economy the state and its innovation policy play an increasingly important role. As innovation development is characterized as a complex one, only State as a central social institute can organize and coordinate synergistic actions of different social structures in scientific, educational, industrial, financial and business spheres (Stradzinskij, 2013). The state should pursue an active policy for the youth in the spheres of education, culture, health, science; it also should form youth pro-active attitudes directed on keeping the culture and history of the past and on creativeness serving country's interests (Evseev, 2011).

An important element of youth involvement in innovative and business activity is an organization of pro-active informational companies by mass media. Rash IT development makes the role of mass media essential in the process of effecting on different spheres of man's life, including youth formation and development. There are several functions of mass media: informational, regulatory, culturological and creative. To excite youth interest to science, innovation and business, a great promotion of scientific, technical knowledge among the youth is necessary. There is a need in impersonal and reliable sources if information in this sphere. Thus, another function of mass media can be added, such as improving the image of scientific activity, innovation and education.

Higher education system is a key element in youth involvement in research and entrepreneurial activities. Thus, universities aim at opening new directions of training and specialties, developing special training courses, constructing laboratories and business incubator zones where students can do practical work. Moreover, Universities establish foresight centers, science parks, centers for entrepreneurship, business clubs. Students are advanced targeted audience for developing innovative activities at universities and it is reflected in the existence of a considerable number of federal education programs directed on youth involvement in innovative and entrepreneurial activities. Furthermore, incentive programs directed on raising innovative and entrepreneurial spirits also play an important role. Thus, higher education should develop skills in the spheres of entrepreneurship, innovative activity and motivate students to take part in these activities.

The third step of the study is a development of a training model aimed at students' preparation for a complex engineering activity based on a problem-oriented training (Fig.2). This training approach is supposed to strengthen a practical training.

The problem-oriented entrepreneurship training is understood as:

- training with an interactive communication between the participants of education process;
- provision of creative students' independence for learning;
- using methods of training and research activities for searching problem situations;
- solution of problems and tasks corresponding to topical issues of science and manufacture;
- diagnostics of engineers' preparedness for a complex engineering activity (Larionov et al., 2014).

The element of this diagnostics is considered to be its usage in foresight training process and the usage of quality assessment scheme of leading global technology producers such as AREVA, Boeing, Toyota, etc for this purpose. Diagnostics of engineers' preparedness for a complex engineering activity is an actual problem of higher education system. The quality of specialist training depends on the level of diagnostic procedure. Preparedness is seen as fundamental initial condition for successful completeness of any activity. By definition preparedness is a mobilization peak of innate human recourses to solve definite problems efficiently. Engineers' preparedness for a complex engineering activity is understood as a complex of an ability to use fundamental knowledge in a project practical activity, formed entrepreneurial competence and ability to foresight the development of technical systems.

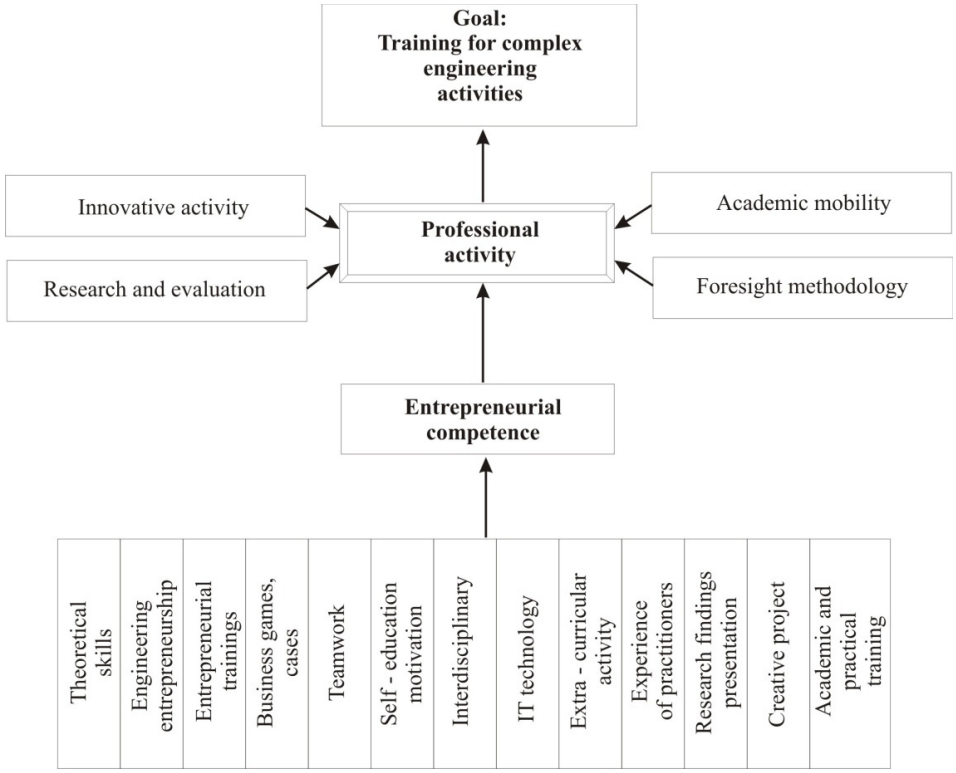

Fig. 2. Training model aimed at students' preparation for a complex engineering activity

Implementation aim of this training model is specialists' training having not only competences in the sphere of fundamental sciences but competences in the sphere of managerial activity, entrepreneurship, innovative development. Future engineers should be competitive in the global world. The main aim is to help researchers and engineers to understand entrepreneur's way of thinking. Entrepreneurship is a source of independence (Allen, 2009).

Entrepreneurship is understood as ability to collect and to use resources needed to capitalize new possibilities connected not only with new technologies, products and services but with the development of new marketplaces, implementation of new managerial methods and so on. Modern studies allow making conclusions that in developed countries 1/3 of economic growth can be connected with entrepreneurship which create the basis for economic stability in all spheres of economic life (Milner & Orlova, 2015).

Specific tool of entrepreneurship is innovation directed on searching new innovations. Entrepreneurs are differed with an innovative way of thinking (Drucker, 1993).

Development of students' entrepreneurial ability is carried out with the unity of training methods, educational technologies, entrepreneurial skills and practical activities. Getting entrepreneurial knowledge the following elements are taken into consideration: preparedness to draw a path of professional activities independently; to have research, analytic, informing and managerial abilities and to build an execution and estimation algorithm.

Together with learning theoretical entrepreneurial knowledge additional pedagogical technologies, methods and practical approaches are used in the training process (Fig. 2). Enterprise study is a means for intelligence development as business activity demonstrates human's mental ability to transform new ideas or investigations into successful innovations, to introduce unconventional approaches and decisions, to realize projects, to transform modern technologies from science into manufacturing industry. Entrepreneurship is connected with creating innovations and innovation creation is connected with creativity. Many inventors and innovators are creative people who are able to create unique technologies. They are curious, persistent, open to new ideas, able to concentrate on

the core of the problem and have great imagination. Creativity is an unexpected, unscheduled new process, idea, language and feeling created by a man. All this is kept thanks to previous experience, study. Human experience consists of a kept part which is reproduced in the forming part. The core of intelligence is not in knowing everything but in searching and testing (Milner & Orlova, 2015). Creativity development in Polytechnic Universities can improve graduates' professional activities in the future. Engineers can perform their duties using unconventional and out-of-the-box approaches, performing projects.

Research work is a key element of suggested learning model. Educators must pay much attention to this work preparing future specialists. Team work of an educator and a student is very important at this stage of training. An educator should use methods of motivation and activation of cognitive and scientific students' activities. Students, post-graduates, young scientists should also be involved in taking part in conferences, olympiads and forums. Discovering of active, interested young people and attracting them to science and innovative activity is a key element of higher education institution development.

The process of engineer's teaching should include the study of Foresight methodology (Fig. 2). American researcher Ben Martin considers that Foresight is systematic attempt to explore science, technology, economics and society future for identifying zones of strategic study and finding new technologies which can bring economical and social benefits in the future (Krasnova & Semushkina, 2008). Thus, it is very important to prepare engineers knowing Foresight methodology and their readiness to use it. Developing new technological systems and products engineers should foresee and take into consideration all possible ways of their realization.

Main engineer's training modules are:

Module of "Identification". As a result of this module study future engineers should foresee possible directions of future technology development. He also should know how to use existed resources and hidden reserves needed to increase the system performance effectiveness in the future (Egorov & Parsadanov, 2001).

Module of "Choice". This training module determines to search better variants of future. Engineers choose the most effective, ideal strategic directions of development and the most promising directions of research and innovation by analysis of all possible variants using definite methods.

Module of "Influence". Due to information received from the first two modules, there is a possibility to understand the ways of forming an ideal future of technical system making right managerial decisions and choosing ideal development directions in the present. Thus, engineers can influence on future in their professional activities (Maksimova, 2014).

Nowadays Foresight methodology is rarely used in Russian Universities. About 60% of the pollees know nothing about this concept. Thus, the study of this methodology should be taught as an independent discipline.

The model suggested in this study (Fig. 2) has an element of lecturers and students academic mobility. This element is an effective addition to engineers' professional activity as academic mobility helps to integrate into global scientific community. International interacademic cooperation stimulates to appear new competences and further self-development.

So, the following possible training results can be distinguished according to the suggested model:

1. Availability to solve applied engineering-and-technical, technical-and-economic issues;
2. Availability to experimental research, managerial, design work connected with realization of multi-disciplinary projects in domestic and international professional activity;
3. Availability to plan, carry out and forecast projects;
4. Availability to use information technologies;
5. Being a team player;
6. Having self-study capacity;
7. Readiness to make decisions in abnormal situations.

4. Conclusion

Necessity of scientific knowledge promotion and youth involvement in innovative and entrepreneurial activity is explained. The model of polytechnic students' training to prepare engineers for a complex engineering and innovative activity is created. Possible training results are distinguished and competences expected within this

model are laid. A key feature of this teaching model is a system approach on the basis of social procurement oriented on promoting new knowledge for projecting the development of technical systems of the future.

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