UDC 378.1

Fostering Professional Competences within Integrated Engineering Education Programs

Saint Petersburg Electrotechnical University "LETI"
V.M. Kutuzov, N.V. Lysenko

V.M. Kutuzov

N.V. Lysenko

The article discloses special aspects of specialists' cycle education. The requirements of employers towards HEI graduates' competences are presented. Types of Centers for Competences executing integrated educational programs are described.

Key words: integrated educational program, graduates' competences, interdisciplinarity.

Main international trends in the development of engineering education lie in the realization of the following principles:

- Interdisciplinarity (integrativeness).
- Informational openness.
- Mobility and variability.
- Internationalization.
- Network cooperation.
- Distance learning.
- Integration of science, industry and society.
- Life-Long Learning.

At the same time, engineering education should be:

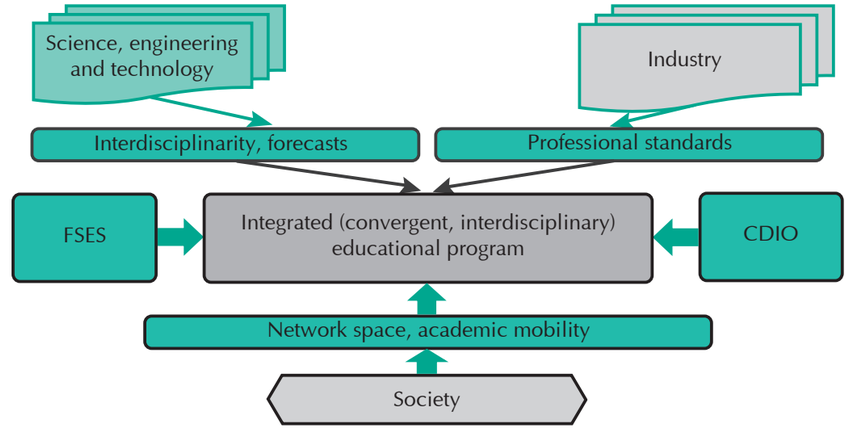
- **forward-looking and advanced** with regard to the dynamically changing engineering and technology;
- **interactive** – allowing students and teaching staff to acquire professional competences of independent exploration, receiving and application of new knowledge within the educational process;
- **integrative** – based on the principles of network cooperation, the integration between different fields of science and technology, and the potential of all the educational process stakeholders.

Realization of these ideas is only possible by means of introducing to the educational process the integrated (interdisciplinary) educational programs, whose content is based on the forecasts in science, engineering and technology, the requirements of professional standards, society and current Federal State Educational Standards – FSES (Fig. 1).

The key problem of realization of the current Federal State Educational Standard lies in the following: Bachelor programs that imply professional activity after receiving the diploma have to have a very prominent practice-oriented character. At the same time, Bachelors willing to continue their successful education at a Master level, have to receive deep fundamental training both generally (physics, math, chemistry) and professionally (in line with the major).

The Saint Petersburg Electrotecnical University "LETI" (SPb ETU "LETI") has a cycle education scheme that provides fundamental background in the framework of unified training in line with the major during the first 2–3 years, and then an opportunity to choose one or another educational profile (specialization) within Bachelor studies after an initial acquaintance with student's possible future professional activities at strategic partner enterprises. After finishing Bachelor education the most prepared graduates, who have succeeded in competitive selection, choose a Master educational program. Their Master education lasts for 2 years in line with the programs, whose contents are approved by employers and reflect modern requirements of labor market, as well as top-notch achievements in one or another field of engineering and technology.

Fig 1. Integrated educational program



For SPb ETU the Master cycle of education is the top-priority educational cycle. The number of budgetary (state-financed) places for Master students is no less than 60% of the number of first-year Bachelor students.

Realization of the cycle training assures a real possibility for flexible adaptation of the study programs' content, selection of an individual learning path, early career-guidance for students. At the same time, a certain updating of the educational process infrastructure is expected to take place, which is be aimed at providing immediate access for each student to the up-to-date knowledge databases, technologies and achievements in science and engineering. The key role in this case is played by an early (almost at the first study year) career-guidance for students, which is provided with the help and direct involvement of employers – university's strategic partners.

The procedure for creating and updating educational programs of Master level and Bachelor profiles (specializations) anticipates the involvement of employers (strategic partners) in the process of fostering required graduates' professional competences, the development of educational content and employers direct involvement in the programs' realization.

Modern professional standards require fostering unordinary graduates' competences as the following ones:

- an ability to depict a scientific world view adequately relating to the modern level of knowledge and based on the known fundamental principles, laws and methods of natural sciences, information and mathematical theories, understanding of the scientific and social essence of problems that occur in professional activities;
- an ability to find organizational and managerial solutions to abnormal managerial situations at small groups of people and readiness to take the responsibility for them;
- an ability to recognize social significance of one's future profession, to have high level of motivation for conducting professional activity, to strive for personal growth, enhancement of one's qualification and mastership, to critically evaluate own strengths and weaknesses, set paths and chose means for reinforcing strengths and dissolving weaknesses;

- an ability to collect, process, analyze and structure scientific and technical information in the field of audiovisual engineering, to apply the developments of domestic and foreign science, engineering and technology, to apply modern program software for development and editing of images and technical drawings, to prepare design and engineering documentation, to conduct feasibility studies for instruments' and systems' projects.

It should be noted that in the professional standards professional competences are described indirectly through working functions, working actions, knowledge and skills (Fig. 2).

Development of a unified informational space assures a distributed network system of cooperation between the university and its strategic partners, Russian and foreign universities, research organizations, i.e. assures the realization of integrated educational programs.

Network cooperation has the following advantages:

- Reacting more rapidly to the external and internal changes due to its ability to reconfigure and attract new participants.
- Focusing activities on the prioritized fields of educational clusters' development.
- Attracting best partners with particular advantages for cooperation.
- Exchanging unique knowledge.
- Creating a "network society".

University designs and develops integrated educational programs as means for fostering professional competences. Focusing on that, and in order to enlarge the prospective functional opportunities of the university, it provides access to the scientific and educational resources, including access to unique equipment and program systems of Centers for Competences, Centers for Prototyping and Centers for Engineering Competences, as well as an opportunity for on-sight communication of educational process participants (Fig. 3).

According to the term, Center for competences is a specific structural unit of an organization, whose function is to control key fields of action by collecting corresponding knowledge and finding ways to apply it in a maximum efficient way.

The role of the Center for competences is to assure integration of knowledge and processes, to give all the interested parties

Fig 2. Structure of a professional standard

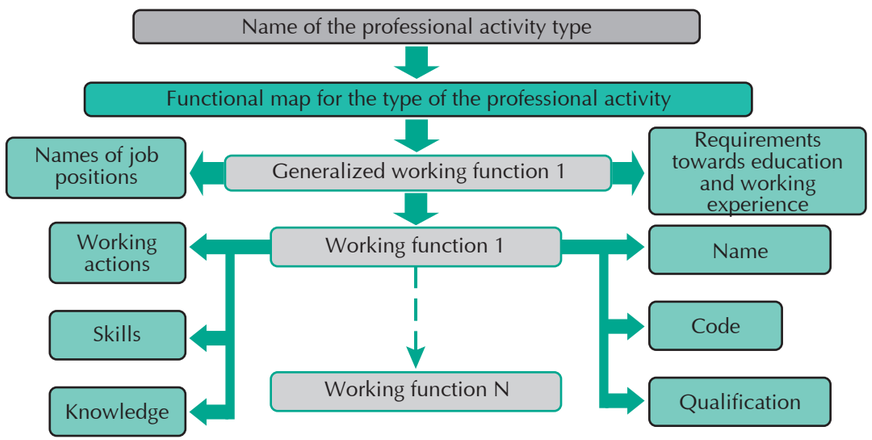
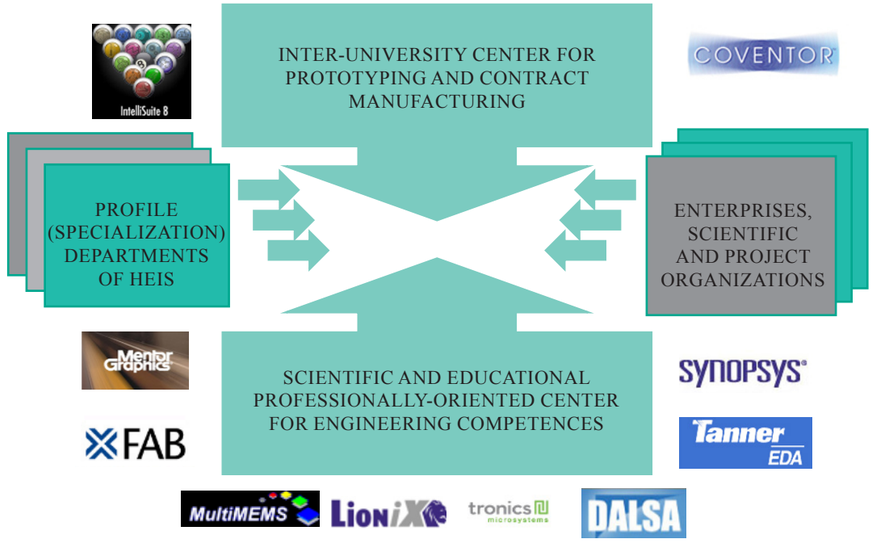


Fig. 3. Professional competence development at centers for engineering competences, prototyping and contract manufacturing



(faculty, top-management, students, and employers) access to the resources and to create an efficient way for communicating. In other words, the Center for Competences works in a way to assure the possibility for operative communication with each other and to receive all the information needed for efficient performance.

The practice shows that there are several types of Centers for Competences that differ according to their key objective:

1. A Center for Competences that works on collecting examples of excellent performance. The main "subjects of interest" of such Center are the so-called best practices that have been performed on one of the core areas of action of an HEI. The Center works on identifying and systemizing such practices, as well as on developing corresponding standards and implementing the received expertise generally.

2. A Center for Competences that aims at development of technological standards. The knowledge acquired by this Center is commonly of the engineering sphere, particularly referring to the development of software, technologies, and equipment. The main objective is to standardize processes, to develop a unified technological platform and interlinked data banks.

3. A Center for Competences that maintains numerous projects and initiatives relating to knowledge management, for instance, staff training on new products and services, assessment of applied technologies, etc.

4. A Center for Competences that supports the overall integration of processes and data for the whole organization. Its aim is to assure staff's global knowledge exchange on a corporate level and recirculation of this knowledge.

Today the humanity is on the edge of a wide spread occurrence of the so-called 6th technological wave [1, 2, pp. 159–166], the essential aspects of which are the following fields of science, engineering and technology:

- Nanoelectronics.
- Molecular and Nanophotonics.
- Nanomaterials and Nanostructured Surfaces.
- Nanosystems Engineering.
- Biotechnologies.
- Information Technologies.
- Cognitive Sciences.
- Social Sciences and Humanities/
- Nano-, Bio-, Info- and Cognitive technologies' convergence (the so-called NBICS-convergence).

The key aspects of the 6th technological wave are the Nanotechnologies and Cell Technologies. According to the prognosis, the main advantage of this wave comparing to the previous one would be a radical decrease of production's power and material consumption and designing of materials and organisms with tailor-made properties.

It is evident that only the development and execution of the integrated (interdisciplinary) educational programs will allow the formation of professional competences needed by a modern specialist.

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UDC 378.126

Interdisciplinarity in Education: Education Programmme Design

Kazan National Research Technological University
L.V. Redin, V.G. Ivanov

The significance of interdisciplinarity in education under the condition of sharp growth in patent activity in developed countries and the increased role of intellectual property items in modern economy are shown. Inderdisciplinarity is based on the network relations among the studied disciplines. Goal, content, and trends in interdisciplinarity are presented in the system of re-training, staff development, and Bachelor's training.

Key words: interdisciplinarity of education, methodology, network, thinking, innovation.

"Systems cannot be controlled,
but they can be created and redone"
D.L. Meadows [1, p. 274]

One of the major modern peculiarities is conditioned by changes in development of social-economic civilization model stipulated by transition from consumer economy and trade in resources, commodities, and services to the society based on knowledge and the priority of knowledge economy (innovative economy).

At present, innovations are introduced in all spheres of life: science, engineering, industry, education, business, and everyday life in the form of new tools and labour conditions, new technological aspects of production, new products and services, new research-production methods, new values, concepts, ways of understanding, complications, and improvements in quality of informative-structural-functional means of organization-management solutions. In general, innovations are conditioned by information technologies that cover all spheres of human life and have a tendency to double capacity within a year – exponential growth (technological singularity, "phase transition") [2].

In this case, the consciousness intensity and trade volume of intellectual property assets rise sharply, first of all, in advanced world powers (USA, China, Japan). Patent activity of leading economic countries is shown in Fig. 1. As seen from the figure below, the advanced countries in the sphere of patent activity have some inflection points in the historical flashback after which there is a sharp acceleration in dynamics of invention applications (Japan – 1950-70; USA – 1985-90; China – 1995-2000).

Rapid growth of patent activity is conditioned by approved national strategy of research-innovative-technological breakthrough due to which a new post-industrial foundation for the country's development is established. State and public innovative-investment resources are concentrated in the strategic spheres providing dissemination of high research and technology knowledge over the whole economic system of the country. It is evident that the sharp growth in patent activity, along with transformations in economic sphere, is connected with changes in education paradigm, as well as development and implementation of innovative educational programmes to foster the commitment to inventive and innovative activities in the participants of economic process. For instance, in the USA in 1990 the programme of formation and development of creative qualities and inventive thinking was adopted, its initiator being the US PATENT and Trademark Office (USPTO) [4]. In

L.V. Redin

V.G. Ivanov