

ENGINEERING EDUCATION QUALITY ASSURANCE IN THE EUROPEAN EDUCATIONAL AREA

Nina Batechko

ORCID iD 0000-0002-3772-4489

Doctor of Sciences in Pedagogy, Associate Professor,
Head of the Department of Higher and Applied Mathematics,
National University of Life and Environmental Sciences of Ukraine,
15 Heroyiv Oborony Str., 03042 Kyiv, Ukraine,
batechko_n_@ukr.net

Mykola Lut

ORCID iD 0000-0003-4187-1323

PhD (Technical Sciences), Professor,
Professor of the Department of Electrical Supply
named after prof. V. M. Syn'kova,
National University of Life and Environmental Sciences of Ukraine,
15 Heroyiv Oborony Str., 03042 Kyiv, Ukraine,
limmit1@ukr.net

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ABSTRACT

The article covers the main principles of the engineers education and ensuring the connection of the proposed educational material with their future engineering activities, the prospects of technical, technological, economic and social development of society. Issues on the quality of educational programs in higher education institutions are briefly outlined. Among the requirements for future engineering activities are considered requirements for the formation of the content of engineering education, its humanization, fundamentalization and professionalization. It is concluded that the most anticipated in the international educational services market are educational and professional programs for training specialists in the scientific and technical field, formed by a list of specialties traditionally for European, African and American countries, whose content and structure corresponds to accepted international requirements. For the formation of a modern domestic engineers' corps it is necessary: to substantially raise the prestige of engineering professions; to ensure the introduction of qualitative changes in the training of engineers, focusing it on the current advances in science and technology, in-depth study of fundamental disciplines, the development of creative and organizational skills of future engineers, their ability to work in conditions of fierce competition; to carry out qualitative improvement of the teaching staff and re-equipment of the training laboratory base; to provide an opportunity to increase the participation of industrial enterprises, research and design institutions in the training of

specialists in engineering; create the legal framework for corporate training of engineers in higher education institutions. In order to coordinate the activities of higher education institutions that train engineers, it would be expedient to broaden the experience of public accreditation of engineering education programs and certification of engineering qualifications and professional engineering activities.

Key words: *competencies; educational program; educational services; engineering education; higher education institution; quality assurance; quality control.*

INTRODUCTION

The problem of the quality of training of specialists with higher education is paramount in the question of their relevance to the national economy and the international recognition of national degrees and qualifications (Poholkov, & Chuchalin, 2004). It is well known that this problem is directly related to the content of education and technologies for the implementation of educational programs.

Engineering education is the most science-intensive in the field of education, since the studied disciplines are difficult to master and, moreover, the knowledge renewal rate is the highest in the spheres of engineering and technology. This causes the need for increased attention to higher education institutions of engineering profile that is the basis of staffing the real sector of the economy.

In the modern world, more and more innovative engineering education is being developed, aimed at forming not only certain knowledge and skills in the field of technology and technology, but also specific competencies focused on the ability to apply them in practice, in real engineering activities, in creating a new competitive products (Agranovich, Chuchalin, & Solovyev, 2004).

Higher education institutions in the world of engineering, in particular European ones, are constantly improving their educational programs and curricula. From the very first year of studies, students are shown a connection between the proposed educational material and their future engineering activities, the prospects for the technical, technological, economic and social development of the society. New content, as well as problem-oriented methods and design-organized learning technologies in engineering education allow to provide its new content, based on a set of competencies, including fundamental and technical knowledge, the ability to analyze and solve problems using an interdisciplinary approach, knowledge of project management methods, readiness for communications and teamwork.

The formation of common approaches to ensuring and assessing the quality of higher education is also one of the directions for the development of the Bologna process in Europe (Grebnev, Kruzhanin, & Popova, 2003). It is assumed that the quality of training of specialists in higher education institutions (HEI) is provided by two main components – the quality of the content of educational programs and the quality of management in a higher educational institution.

FORMATION OF REQUIREMENTS FOR FUTURE ENGINEERING ACTIVITIES

The analysis of the factors determining the development of engineering education (Fig. 1) shows that it should be based on:

- the analysis of fundamental changes and reforms in the scientific, technical and socio-economic sphere on the threshold of the XXI century (sustainable development, the imperative of the “survival” of humanity, anthropoeconomics, technological development, the formation of an educational society, the development of practical-oriented integrated polydisciplinary sciences, informatization and mediatization of society, etc.);
- the forecast of substantial and structural changes in the country's production, science and culture, as well as the educational needs of the population;
- the study of the processes of the formation of a mixed economy of the country and the directions of regional economies development;
- system-based representation of the goals and values of the engineering activities of the future;
- taking into account the philosophy of vocational education, consisting of:
 - studying the state and dynamics of the engineering and intellectual products market at the regional, interregional, national and international level;
 - taking into account the role of the personal organization of the professional engineer in shaping the thinking of the engineering type, in his own way of entering the engineering culture, in setting himself up for self-development and professional creativity.

In general, the system of engineering education is designed to provide: creating the conditions for the evolutionary cultivation of a new generation of highly educated engineering professionals able to realize sustainable dynamic development of the economy and the breakthrough development of various practical areas based on high educational and knowledge-intensive technologies; training of specialists for whom the orientation on self-development, professional skills, development of an individual style of activity are priorities throughout their lives. The new generation of engineers must be actively and socially protected by the quality of education from the real danger of a person turning into a variable technology material.

The system of requirements, described with the help of the tree of engineering goals, should be transformed into requirements for the level of preparedness of persons who completed training in the direction (specialty) program and fixed in the state educational standard.

Article 10 “Standards of higher education” of the Law of Ukraine “On Higher Education” (2014) contains the following definitions:

“1. The standard of higher education is a set of requirements for the content and results of educational activities of higher educational institutions and scientific institutions for each level of higher education within each specialty.

2. Higher education standards are developed for each level of higher education within each specialty in accordance with the National Qualifications Framework and are used to determine and assess the quality of the content and

results of educational activities of higher educational institutions (scientific institutions).

3. The standard of higher education defines the following requirements for the educational program: 1) the amount of ECTS credits required to obtain the appropriate degree of higher education; 2) the list of a graduate's competencies; 3) the normative content of the preparation of applicants for higher education, formulated in terms of learning outcomes; 4) forms of attestation of applicants for higher education; 5) requirements for the availability of the internal quality assurance system for higher education; 6) requirements of professional standards (if available)".

FACTORS determining the development of higher education	
	<ul style="list-style-type: none"> • cardinal reformative shifts in the scientific, technical and socio-economic fields • sustainable development • the imperative of the "survival" of humanity • anthropoeconomics • technological development • formation of an educational society • development of practical oriented complex multidisciplinary sciences • informatization and mediatization of society
	The forecast of substantial and structural changes in production, science and culture of the country and the educational needs of the population
	The processes of formation of a mixed economy of the country and directions of development of regional economies
	Goals and values of engineering activities of the future
	Philosophy of Professional Education
	The market for engineering and intellectual products at the regional, interregional, national level and internationally
	Personal orientation of the youth to engineering professions

Figure 1. Factors defining the development of higher engineering education

FORMATION OF THE CONTENT OF ENGINEERING EDUCATION

Competition in the intellectual labor market poses problems for engineering universities to meet the market demand for specialists of a certain level and quality of training.

The educational policy of HEI in these conditions should be aimed at training competitive specialists, socially protected by professional and educational opportunities of the received education and its quality, as well as comprehensively prepared, as a person, to work in conditions that are constantly changing.

However, the successful solution of these problems and the productive organization of HEI activities in the intellectual labor market is practically impossible to implement only on the basis of the mandatory minimum requirements for the level of training for graduates, which are established by the state educational standard.

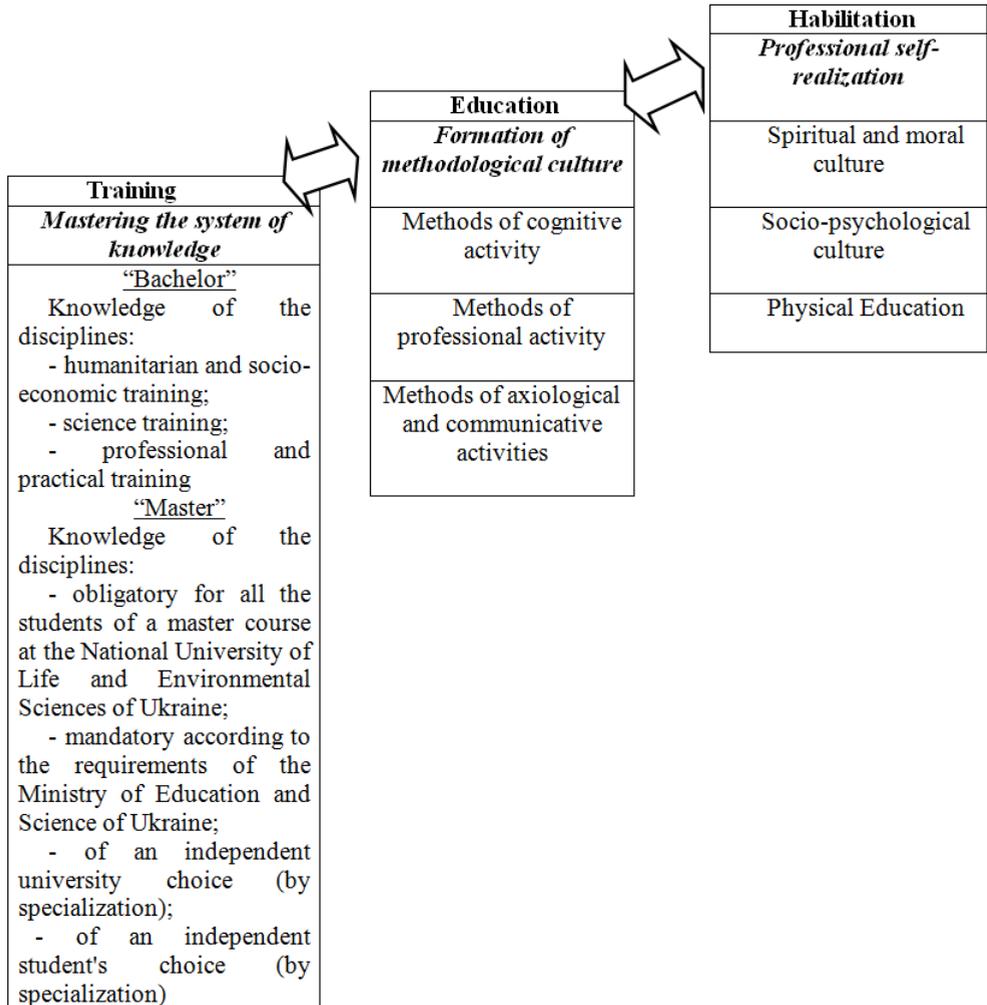


Figure 2. The structure of the educational and professional training program (for example, the National University of Life and Environmental Sciences of Ukraine)

Scientists have formed the basic requirements for the content of the educational institution of a higher education institution being created for the first time, according to which it should contain a fractally organized set of components (Fig. 2):

- training (Fig. 3), which ensures the assimilation of the system of humanitarian and socio-economic, mathematical and natural-scientific, general-professional and special-professional knowledge at a given level;
- education (Fig. 4), which provides, along with education, the formation of a graduate methodological culture, mastering it at a given level of formation of methods and methods of cognitive, professional, communicative and axiological activities;
- habilitation (Fig. 5), which provides, along with training and education, a comprehensive preparation of the individual for professional activity, as well as its professional self-realization.

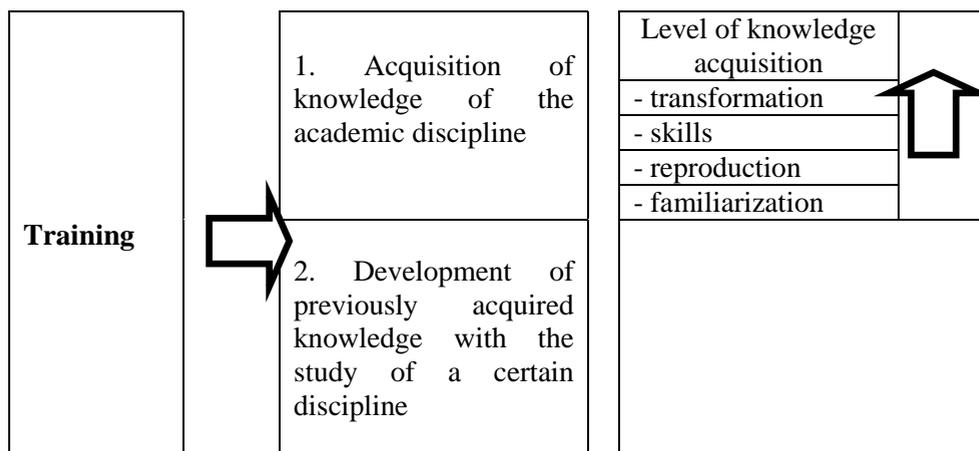


Figure 3. The structure of the component "training" in the training of specialists

The formation of a professional engineer from a student requires his exit from the environment of knowledge into the environment of activity and life realities.

Under such circumstances, the system of knowledge obtained by the future engineer should be different: strong natural science, mathematical and ideological foundation of knowledge; the breadth of interdisciplinary system-integration knowledge about nature, society, thinking; a high level of general professional and special professional knowledge, which ensures the activity of a specialist in problematic situations and makes it possible to solve the problems of training specialists with increased creative potential.

The traditional understanding of vocational education as the assimilation of a certain amount of knowledge, based on the teaching of the disciplines provided by the curriculum, is clearly insufficient. The basis of higher engineering education shouldn't include academic disciplines to such an extent but the ways of thinking and activity. Knowledge and methods of knowledge, as well as activities must be combined into organic integrity. This requires the inclusion into the requirements for the content and level of training of engineers of the questions on formation of a methodological culture, including methods of cognitive, professional, communicative and axiological activities (Fig. 4).

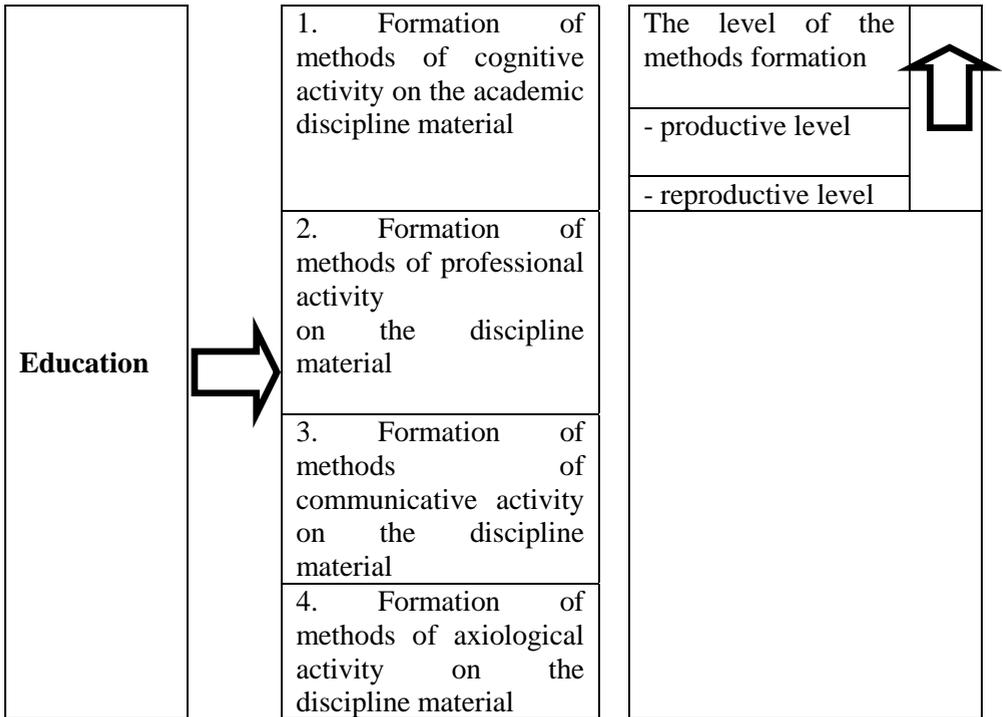


Figure 4. The structure of the component “education” in the training of specialists

Developing a system of methods as one of the components of the educational standard, it is important to set the level of mastering the method, it is advisable to differentiate into two classes:

- 1) reproductive (provides a known result by known means);
- 2) productive (provides the setting of new goals and the creation of appropriate means or achievement of known goals with the help of new means).

The characteristic feature of engineering education should be a high level of methodological culture, a perfect and creative mastery of cognitive methods and activities.

Along with this, as experience in training specialists shows, the success of the activities of engineers is largely determined not only by a high level of knowledge, productive knowledge of cognitive methods and activities, but also by comprehensive preparation for professional work. It is said not only about preparing for professional activities in normal life conditions and well-functioning manufacturing, but also about preparing for trials, lifestyle changes, for a repeated change of one's ideas, outlook and world perception. Thus, successful professional activity involves not only a high level of training and education, but also a high level of spiritual, moral, socio-psychological and physical culture of a person. A higher educational institution in such a situation should become not only a center of education and science, but also a center for habilitation of the personality, its professional development and self-realization (Fig. 5).

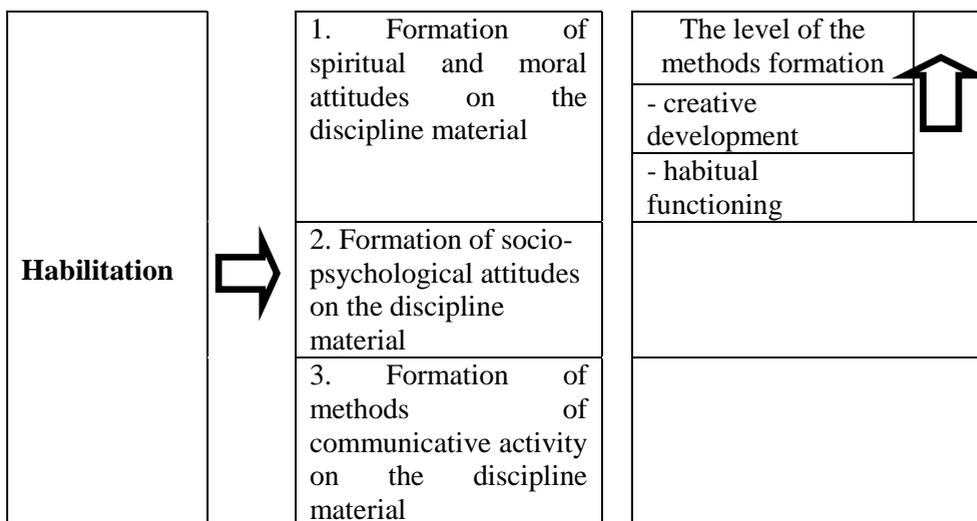


Figure 5. The structure of the component “habilitation” in the training of specialists

Designing the content of education and the requirements for the level of training of engineers, it is necessary to find a place for a system of knowledge and methods aimed at solving problems of self-knowledge and self-realization of a person.

Of great importance in shaping the content of engineering education are its humanization, fundamentalization and professionalization.

Humanitarization of higher engineering education is based on the following principles:

- orientation of the engineering education system to the creation of conditions for the spiritual, moral and cultural self-development of an individual;
- deep fundamental and methodological training of engineers in the field of humanitarian knowledge, the spiritual life of man and society;
- the development by students of the methodology of knowledge and creativity, practical activities, social behavior and self-development of the individual as the decisive conditions for achieving success in life;
- creation of prerequisites for the organic inclusion of engineers in the economic, social and cultural processes of the development of world civilization;
- the development of future professional activities by students as a unity of physical, economic, social, socio-psychological and noospheric patterns and an assessment of the usefulness of artificial environments created from the standpoint of historicism, the priority of universal human values, humanism, a generalized approach;
- the organic connection of the educational process with extracurricular work, the sphere of leisure and recreation of students, the wide involvement of science and culture, art and religion, politics, law and other spheres of public life in teaching at a university;
- democratization of the entire system of engineering education, political and ideological pluralism, a combination of the basic and variable components

of the primary process, individualization of education in accordance with the needs of the student's personality;

- internationalization of engineering education.

The value-semantic characteristic of the humanitarization of engineering education is ensuring a harmonious unity of the natural science and humanitarian culture of knowledge and activity, the unity based on mutual understanding and dialogue.

The most important task of the system of engineering education in this regard is to create the conditions for the revival of a single natural-scientific and humanitarian culture of knowledge and activity.

Fundamentalization of higher engineering education includes:

- the increase in the volume and role of disciplines of the general scientific cycle, the strengthening of links between the disciplines of the curriculum that should contribute to the education of the systemic thinking of a specialist, awareness of the need for the development and implementation of new technology, technology, equipment, etc. as well as taking into account economic, social, political and other factors;

- reorganization of the cycle of professional disciplines, consisting:

- firstly, in increasing the attention in these disciplines to methodological, ideological and social problems;

- secondly, in the study of private factors, individual patterns of phenomena and concepts, theoretical propositions based on generalizing (fundamental) ideas and principles characteristic of this science;

- thirdly, in the transition from analysis to the synthesis of design solutions, their optimization and mathematical modeling in special courses;

- ensuring formation in the educational process of methodological culture of a specialist, which includes methods of cognitive, professional, communicative and axiological activity;

- the study of special disciplines aimed at developing sustainable skills in the use of means and technology of information culture, as well as disciplines aimed at mastering by students of rational methods of knowledge acquisition.

The professionalization of higher engineering education is directed at the preparation of a new type of specialist – a professional, carrier of integrated scientific and technical activity, characterized by global thinking, encyclopedic knowledge, aristocracy of spirit, the capability of doing creative work at all stages of the life cycle, the creation of systems from research and design to the development of technology and entrepreneurial activity.

Professionalization is achieved in the real practice of education through the development of engineering, mastering of engineering culture and practice-oriented training (system methodology, conceptual design, development programming).

In the development of modern engineering education, one must also consider the full range of problems for improving the language training of engineers (Poholkov, & Chuchalin, 2004). It is necessary to revise the goals, content and technology of teaching foreign languages in the system of engineering education, to ensure the solution of issues of increasing the motivation of learning foreign languages, strengthening the material and technical base and staffing, attracting to higher education institutions of engineering profile of specialists of all profiles who are fluent in a foreign language, developing multi-

level personality-oriented system of foreign language training of the students and the formation of active information and learning environment in higher education institutions, etc.

The main targets in the state educational standard should be the practical knowledge of a foreign language as a means of intercultural communication, which provides:

- continuing education and professional activities in a foreign language environment;
- communicative and linguistic competence in common situations of everyday communication with direct contact with native speakers;
- fluent reading and fluent understanding of newspaper and magazine articles, television and radio programs, business writing skills, negotiation and contract writing skills;
- professional competence in translating original technical literature in the specialty, in lecturing and reports, writing scientific articles in a foreign language.

The formation of a high level of information culture in the system of engineering education is on the threshold of the third millennium a necessary requirement for ensuring the productivity of engineering activity.

Information intellectual technologies, accumulated information resources in the form of databases and knowledge, information and logical models, enormous computing power and means of global telecommunication communication create the basis for abandoning the functional division of labor in scientific and technical activities and provide for the first time in the history of mankind opportunities for creating complex systems in the creative laboratory of one person.

THE QUALITY OF ENGINEERING EDUCATION MAINTAINING

It is necessary to develop an integrated system for maintaining the quality of engineering education at a socially significant level, the elements of which are shown in Fig. 6. The transition to new educational technologies in the training of engineers (Basic principles of the national doctrine of engineering education [Electronic resource]).

The key to the implementation of the doctrine of engineering education is the search for and the creation of non-traditional technological social and educational decisions, the use of ideas and fundamentally new, “high” educational technologies that provide multiple increases in the efficiency of the teaching staff, the creation of technologies for mass production of talent, the use of remote teaching.

Nowadays, in the whole world in the training of engineers, there is a rather radical transition from the “school of memory” to the institute, in which students are taught to work with their own thinking.

The transformation of the system of engineering education to the development of methods of cognitive and engineering activities, communication and engineering culture radically changes the idea of the institution of higher education with its educational process. The most important direction in the development of engineering education is the special organization of the student’s work during the entire training at the HEI in complex

multidisciplinary practice groups, the organic inclusion of students in active creative activities, ensuring their mass participation in research activities, and creation of goal-oriented forms of education. All this should create prerequisites for an evolutionary transition in engineering education from an educational (school of memory) to a scientific-educational process. The scientific and educational process can be represented as a system of creative workshops of reputable scientists, leading future engineers. At the same time, a constantly updated community of students, candidates for undergraduate, master's degrees and engineering degrees, graduate students and doctoral students form a holistic creative team, an appropriate scientific school, where continuity is realized in the methodology of cognitive activity, the development of ideas about the world and the place of man in the world, about ideals, values and the goals of scientific and engineering work are consolidated and transmitted to the traditions of the art of research and engineering activity through and during the study itself.

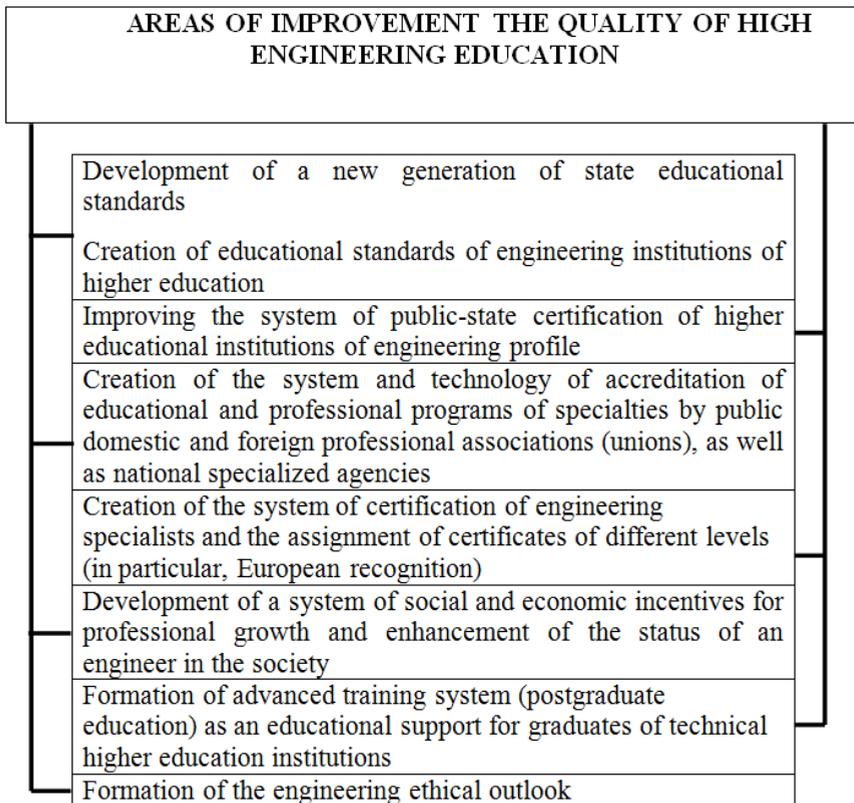


Figure 6. Areas of improvement of the quality of higher engineering education

Modern educational technologies in the engineering education system organically include broad academic mobility.

At present, the self-sufficiency of a university in any country is being justly criticized for the preparation of a professional engineer who is competitive in the world market of intellectual labor, and there is a recognized need to expand the academic mobility of students to improve the quality of training. In the

system of engineering education in Ukraine, academic mobility of students is underdeveloped, of course, it needs to be corrected. In foreign higher education institutions, academic mobility has received wide development and the necessary state support. In a number of countries (for example, Germany), training and internships for students at domestic and foreign universities is an indispensable element in the way of obtaining full-fledged vocational education. Institutions of higher education in the United States are widely practicing contractual relations between universities to expand opportunities for academic mobility of students within the country.

In Ukraine, the Union of Civil Engineers of Ukraine, the Scientific and Technical Society of Power Engineers and the Electrical Industry (NTTEiEP), the Ukrainian Association of Electrical Engineers, the All-Ukrainian Public Organization “High Council of Energy Auditors and Energy Managers of Ukraine”, the Ukrainian Association of Agricultural Engineers and other public engineering organizations could join their efforts in the solution of a number of academic mobility problems.

It is necessary to use more actively the “included” studies abroad, “route” technologies of studying, including using telecommunication means, the exchange of leading scientists and professors between domestic and foreign higher educational institutions. Recently, higher educational institutions in different countries have been working intensively to enter the international market for educational services in both traditional and distance education.

To date, the international market of educational services has developed a fairly tough competition of HEIs. According to experts, the United States today controls from 30 to 40 percent of the international market for educational services. In this market, nearly 3,000 American higher educational institutions are successfully operating, and one thousand and more than a thousand foreign students study in 80 American HEIs. The preparation of foreign students in the US HEIs has become a major source of income for the development of higher education and the country's economy.

Currently, the most expected in the international market of educational services are the educational and professional training programs for specialists in the scientific and technical sphere, formed according to the nomenclature of specialties traditional for European, African and American countries, the content and structure of which meet accepted international requirements.

The educational and professional programs created with regard to the specified requirements of the international educational services market make it possible to prepare a highly qualified specialist, but, as a rule, do not fully meet the individual, possibly non-existent requirements of state educational standards, do not allow those who have successfully completed training to issue a state diploma. This situation largely closes the exit of universities of Ukraine to the international market of educational services.

When developing a new generation of state standards, it is necessary to take into account these contradictions and to build a system of state educational standards, consistent with international practice of training.

CONCLUSIONS

1. For the formation of modern domestic engineers it is necessary: to raise substantially the prestige of engineering professions; to ensure the introduction of qualitative changes in the training of engineering personnel, orienting it to the modern achievements of science and technology, in-depth study of fundamental disciplines, the development of creative and organizational skills of future engineers, their ability to work in conditions of tough competition; to make qualitative improvement of the teaching staff and re-equipment of the training laboratory base; to provide an opportunity to intensify the participation of industrial enterprises, research and design institutions in the training of specialists in engineering; to create legal bases for corporate training of engineers by higher education institutions.

2. In order to coordinate the activities of higher educational institutions that train engineering specialists, it would be advisable to introduce more widely the experience in public accreditation of engineering educational programs and certification of engineering qualifications and professional engineering activity.

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ЗАБЕЗПЕЧЕННЯ ЯКОСТІ ІНЖЕНЕРНОЇ ОСВІТИ В ЄВРОПЕЙСЬКОМУ ОСВІТНЬОМУ ПРОСТОРІ

Батечко Ніна, доктор педагогічних наук, доцент, завідувач кафедри вищої та прикладної математики, Національний університет біоресурсів і природокористування України, вул. Героїв Оборони, 15, 03042 Київ, Україна, batechko_n_@ukr.net

Лут Микола, кандидат технічних наук, професор, професор кафедри електропостачання імені проф. В. М. Синькова, Національний університет

біоресурсів і природокористування України, вул. Героїв Оборони, 15, 03042 Київ, Україна, limmit1@ukr.net

У статті висвітлюються основні засади підготовки інженерних кадрів і, зокрема, забезпечення тісного зв'язку пропонованого навчального матеріалу з їх майбутньою інженерною діяльністю, перспективами технічного, технологічного, економічного та соціального розвитку суспільства. Стисло викладені питання щодо якості освітніх програм у закладах вищої освіти. Серед вимог до інженерної діяльності майбутнього розглядаються вимоги щодо формування змісту інженерної освіти, її гуманітаризації, фундаменталізації та професіоналізації.

Зроблено висновок, що найбільш очікуваними на міжнародному ринку освітніх послуг є освітньо-професійні програми підготовки фахівців в науково-технічній сфері, сформовані за традиційною для європейських, африканських і американських країн номенклатурою спеціальностей, зміст і структура яких відповідає прийнятим міжнародним вимогам. Для формування сучасного вітчизняного корпусу інженерів необхідно: суттєво підняти престиж інженерних професій; забезпечити внесення якісних змін у підготовку інженерних кадрів, зорієнтувавши її на сучасні досягнення науки і техніки, поглиблене вивчення фундаментальних дисциплін, розвиток творчих і організаційних навичок майбутніх інженерів, їх здатності працювати в умовах жорсткої конкуренції; здійснити якісне поліпшення професорсько-викладацького складу та переоснащення навчально-лабораторної бази; забезпечити можливість активізації участі виробничих підприємств, науково-дослідних і проектно-конструкторських установ у підготовці фахівців інженерного профілю; створити правові основи для корпоративної підготовки інженерів вищими навчальними закладами. З метою координації діяльності закладів вищої освіти, що готують фахівців інженерного профілю, було би доцільним ширше впроваджувати досвід з громадської акредитації інженерних освітніх програм та сертифікації інженерних кваліфікацій і професійної інженерної діяльності.

Ключові слова: заклад вищої освіти; інженерна освіта; компетенції; освітні послуги; освітня програма; управління якістю; якість освіти.

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